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NATIONALGEOGRAPHIC.COM/MAGAZINE

JULY 2004

# NATIONAL GEOGRAPHIC

## SUN bursts

HOT NEWS FROM OUR  
STORMY STAR

YEMG

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Olympic, a Gold Medal Park 56  
Toe-to-Toe With Tanzania's Elephants 76  
Wind Scorpions, Desert Speedsters 94  
Peru's Temple of Doom 102  
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Special Sun Supplement





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**SPECIAL SUPPLEMENT: THE SUN**
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BY DEMETRA AOSPOROS PHOTOGRAPHS BY GILLES NICOLET
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- 102 Temple of Doom** In a mud-brick pyramid on the coast of Peru, elaborate reliefs tell a gory tale of human sacrifice and offer insights into the Moche culture, which vanished 500 years before the Inca.  
BY PETER GWIN PHOTOGRAPHS BY IRA BLOCK
- 118 ZipUSA: Nalcrest, FL** Neither rain nor heat nor gloom of night stops folks from living large at the unofficial retirement community of the National Association of Letter Carriers.  
BY MELBA NEWSOME PHOTOGRAPHS BY DAVID MCLAIN

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### THE COVER

A fountain of superheated gas called a prominence extends 200,000 miles from the sun.

BY SOHO/EIT, ESA/NASA

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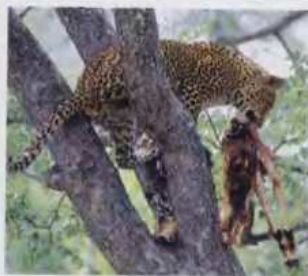


EVERY SUNDAY NIGHT

**NGC Presents** Tune in Sunday evenings for the best of the Channel, from Peru's hidden pyramids to the mystique of the Kennedy clan. Also on tap this month: Host David Attenborough explores the seven continents to celebrate Earth's masterpieces of stone, sand, lava, and ice—such as Australia's Twelve Apostles (left)—in *Greatest Natural Wonders*.

WEEKNIGHTS, 7:30 P.M. ET

**Totally Wild** Nature at its most surprising and bizarre is the star in an action-packed series showcasing the marvels of animal behavior. The cast includes swimming elephants, dueling walruses, leopards that haul their prey high into trees (right), catfish that walk on land, and beetles that squirt blood from their eyes. Every week *Totally Wild* brings you unusual behavior seldom captured on film.



## NG Television & Film

NATIONAL GEOGRAPHIC ULTIMATE EXPLORER, MSNBC, SUNDAY, JULY 4 8 P.M. ET/PT

**Shark Sonics** How do you get close to great white sharks? Correspondent Mireya Mayor joins underwater cinematographer Bob Cranston off the coast of Baja California as he tests an ingenious device that uses sound to attract sharks. When great whites arrive, they circle Mayor in a cage (right), and Cranston risks his life to film the predators in open water.



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**CULTURE: THE PHOTOGRAPHER'S VISION**

**TAKE IN THE LOCAL COLOR AT OUR PHOTO GALLERIES** At the Culturally Speaking site, get photographers' eccentric takes on New York City, Mexico, and in mid-July, Greece. ■ **POSTCARDS AND WALLPAPER** Send or save images from the galleries. [nationalgeographic.com/insights](http://nationalgeographic.com/insights)

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# From the Editor



WILLIAM LIVINGSTON, NATIONAL SOLAR OBSERVATORY; RECORDED IN VISIBLE LIGHT WITH YELLOW FILTER

My first great look at the sun—other than in the pages of NATIONAL GEOGRAPHIC, of course—came in 1974 at Kitt Peak National Observatory near Tucson, Arizona. As I gazed at the brilliant disk projected onto a viewing table of the McMath-Pierce Solar Telescope, I was fascinated by the shimmering surface and dark sunspots. And I was glad that astronomers dedicate their lives to finding new ways to do what we were rightly warned not to do as children—look at the sun. These men and women are solving some of the mysteries of our star.

What kinds of mysteries? Here's one: It's hotter tens of thousands of miles from the sun than at its surface. (You'll find the latest explanation on page 29.) Understanding the sun and its "space weather" isn't just of interest to scientists. Protecting power grids, communications satellites, and astronauts can depend on knowing when the sun will flare, suddenly ejecting megatons of energy.

The world's leading solar astronomers helped us prepare our cover story and its accompanying supplement. So if you want to learn how secrets 93 million miles away are being unlocked, turn to page 2. Just one piece of advice: Don't forget the sunscreen.

*Bill Allen*

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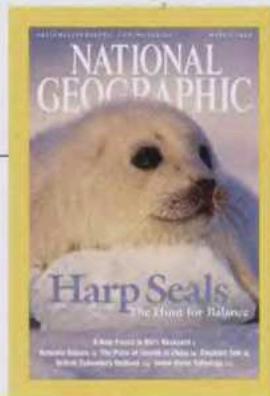
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# Forum



**March 2004**

*"Armenia Reborn" inspired more than 1,600 letters—the most mail elicited by any one story in the past five years. Mail streamed in from Turks around the world (many of whom participated in letter-writing campaigns) protesting as biased our reporting on the 1915 Armenian genocide by Ottoman forces and relations between Turkey and Armenia. Hundreds of Armenians responded with praise for the story.*

**Armenia Reborn**

I felt deeply disturbed and saddened by the uniformly prejudiced and slanted presentation of facts and events. Significant scholarship on this sad chapter of history fails to corroborate the Armenian allegations against the Turks. There are two entirely different narratives about these tragic events of long ago. It is only through direct dialogue that the Turks and the Armenians will be able to address these issues and renew their centuries-old friendship.

There is no excuse for insulting the memory of Turkish diplomats murdered by terrorists. Callously referring to their murders "... allegedly by Armenian terrorists," when in the United States alone several were found guilty and are serving prison terms, is reprehensible and legally irresponsible.

"Armenia Reborn" also does injustice to the Nagorno-Karabakh conflict between Armenia and Azerbaijan. Armenia's responsibility in this respect is fully established in the various resolutions of the UN Security Council and other international bodies. NATIONAL GEOGRAPHIC should have insisted on a higher level of objectivity before printing "Armenia Reborn" and owes it to its readers to set the record straight on Turkey.

O. FARUK LOĞOĞLU  
*Ambassador to the United States  
Embassy of Turkey  
Washington, D.C.*

*While the majority of the assassinations of Turkish diplomats remain unsolved, Armenian terrorists have been convicted in some of these crimes. Therefore, our use of the word "allegedly" to apply to all cases was incorrect.*

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The article captured the essence of the Armenian identity historically and the values that animate our people today. As for the cataclysmic event in our past—the Armenian genocide under cover of World War I—NATIONAL GEOGRAPHIC has not only told the truth, but is also in good company. One hundred and



### Harp Seals

I am sure that the beautiful pictures of the baby harp seals are going to inspire hordes of well-meaning people to once again start protesting the Canadian seal hunt. I wonder how they would feel if they saw the pictures of the many families who are driven to poverty because of the cod fishery being shut down due to these "innocent" seals. I guess that is not as pretty a picture and would not sell as many copies of NATIONAL GEOGRAPHIC.

CHERYL HICKMAN  
*St. John's, Newfoundland*

I was very disappointed to read about the Canadian seal hunt as though it were a worthwhile undertaking. Fishermen have proved their willingness to exploit the

resources they depend on for a living by over-harvesting cod. Combine their greed with the threats of a natural decline due to climate change, and I can see no point in continuing the hunt of those immature animals.

JARED RUBIN  
*Las Vegas, Nevada*

Last year I traveled to the Arctic to bow hunt for musk ox with Inuit guides. The Inuit were aware of the ban on seal products in the U.S., but they were clearly vexed by it, as am I. The seals in the area I traveled are incredibly numerous, and I believe seal populations could thrive with proper management.

THOMAS M. BASCH  
*Grand Rapids, Michigan*



BRIAN SKERRY

I find it difficult to be sympathetic to the fishermen's desire "to maintain a way of life they cherish," when that lifestyle involves clubbing young seals to sell their pelts to an industry that caters to the whims of the fashion world. Perhaps there would be less demand for "fashionable" furs if the would-be wearers were required to deliver the death blows themselves.

WARREN WRIGHT  
*Napanee, Ontario*

twenty-six Holocaust and genocide scholars signed a petition on March 7, 2000, calling the Armenian genocide "an incontestable historical fact." As recently as February 2003, the International Center for Transitional Justice concluded that what happened to the Armenians includes "all of the elements of the crime of genocide . . . and legal scholars as well as historians, politicians, journalists and other people would be justified in continuing to so describe them." The "controversy" today lies squarely with

the Turkish government as it continues to attempt to coerce the world to be complicit in its denial. Turkey's aspiration to be accepted as a full member of the European society will not be realized without facing its own history—just as coming to terms with accepting the destruction of Native Americans and the stain of slavery made America what it is today: more humane and just.

HIRAIR HOVNIANIAN  
*Chairman, Board of Trustees*

ANTHONY BARSAMIAN  
*Chairman, Board of Directors  
Armenian Assembly of America  
Washington, D.C.*

Thank you for the well-researched, accurate, and fair Armenia article. Both my parents were survivors of the genocide of 1915. Their parents perished,

burned alive in the church where they had taken refuge. Turkey consistently denies these killings, but articles like Frank Viviano's bring justice and perspective to our history. Acknowledging past wrongs makes the healing process possible.

LUCINE ZADOIAN KOUGHAKDJIAN  
*Arlington, Massachusetts*

The Republic of Armenia will remain an underdeveloped nation with staggering emigration until its neurotic obsession with past misfortunes recedes.

BRUCE FEIN  
*Washington, D.C.*

### China's Growing Pains

As a Chinese, I am proud of my country's long history and achievement. However, there is no point denying that we have an environmental disaster that

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is devastating to our people's current and future well-being. I went back to China in 2001 with my family, and I was so delighted to see the great changes everywhere. People's lives have improved significantly since I left in 1992. Yet I was dismayed to see the hazy sky in Beijing, piles and piles of trash in the outskirts of the city, and open sewage running everywhere. It's important that we face the problem and find a long-term solution. There is nothing wrong with working hard for a better life for ourselves and for our children, but a better quality of life depends on a clean environment.

GINGER FISHER

*Cook, Nebraska*

FROM OUR ONLINE FORUM

nationalgeographic.com/magazine/0403

When I read your piece, I was ashamed to be part of the Chinese population. If only the government would give up the idea of westernization just for a bit and work on improving the health and well-being of its citizens, China would gain so much more respect from the world. Because of China's hunger for Western lifestyles and greed for being the best, the cost will be a huge burden on many generations to come.

Y. LONG

*Burlington, Ontario*

To North American readers who have little knowledge of the history of China and its transformation in the past decades, the article must seem like just another confirmation of their view that China is a miserable place that exploits the poor to produce cheap goods for the United States. Nothing can be further from the truth. I have traveled in China as an international business consultant and a tourist. It is making huge strides in alternative energy. China's problems are inherited from a colonial and feudal past. Historians agree that China in the 16th century was among the most prosperous and advanced countries in the world, but three centuries of foreign invasion and domination destroyed Chinese development. The British opium trade with China also contributed. Without such background, your article is misleading.

KENNETH ABEYWICKRAMA

*Silver Spring, Maryland*



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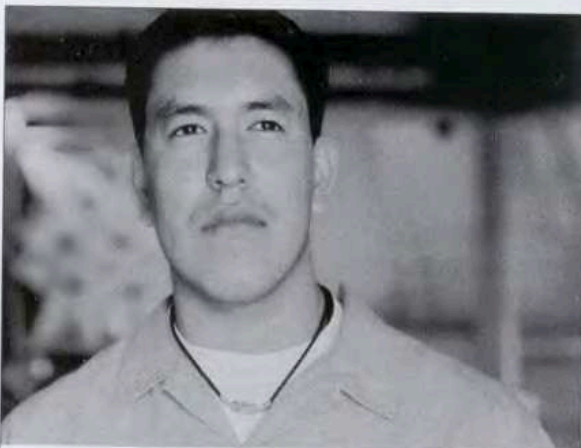
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**Geographica: Murder Most Beastly**

You state that hunters "cash in on the market for bear gallbladders" and refer to a hunter making "an illegal kill in a national park." Hunters did not commit these crimes. Poachers did. Hunters abide by rules set by local authority. Poachers follow no regulations. Hunters generate millions of dollars for conservation. Poachers only take.

MARK COOPER

*Independence, Missouri*

I have been monitoring the rhino horn trade between Africa and Yemen since 1978. I read with great dismay in *Geographica* that the cost in Yemen for a kilo of black rhino horn is \$60,000. The correct price is \$1,200. By your stating this very high price for rhino horn, poachers and traders will have a greater economic incentive to kill rhinos and send their horns to Yemen. The South African press has published high prices for rhino horn, which some conservationists believe has encouraged poaching of rhinos.

ESMOND BRADLEY MARTIN

*Nairobi, Kenya*

*Black market prices vary widely throughout Asia. Upon further investigation, however, the \$60,000 figure appears high for Yemen.*

The text says shell casings are shown in the foreground of the photograph of the confiscated polar bear. The picture shows bullets and complete cartridges, but no shell casings.

TED WARNICA

*Grand Junction, Colorado*

**Geographica: Right (or Left) of Way**

Thinking I was clever, I was about to point out that Bermuda, one of the few countries in the world where motorists travel on the left side of the road, was not highlighted on your map. However, on closer inspection, I discovered that your map does in fact portray Bermuda—the tiniest of dots that can only really be spotted using a magnifying glass.

DAVID ALLENDER

*Emerald Beach, New South Wales*

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# G E O G R

T H E P E O P L E , P L A C E S , A N D





# APHICA

CREATURES OF OUR UNIVERSE

EXPLORATION

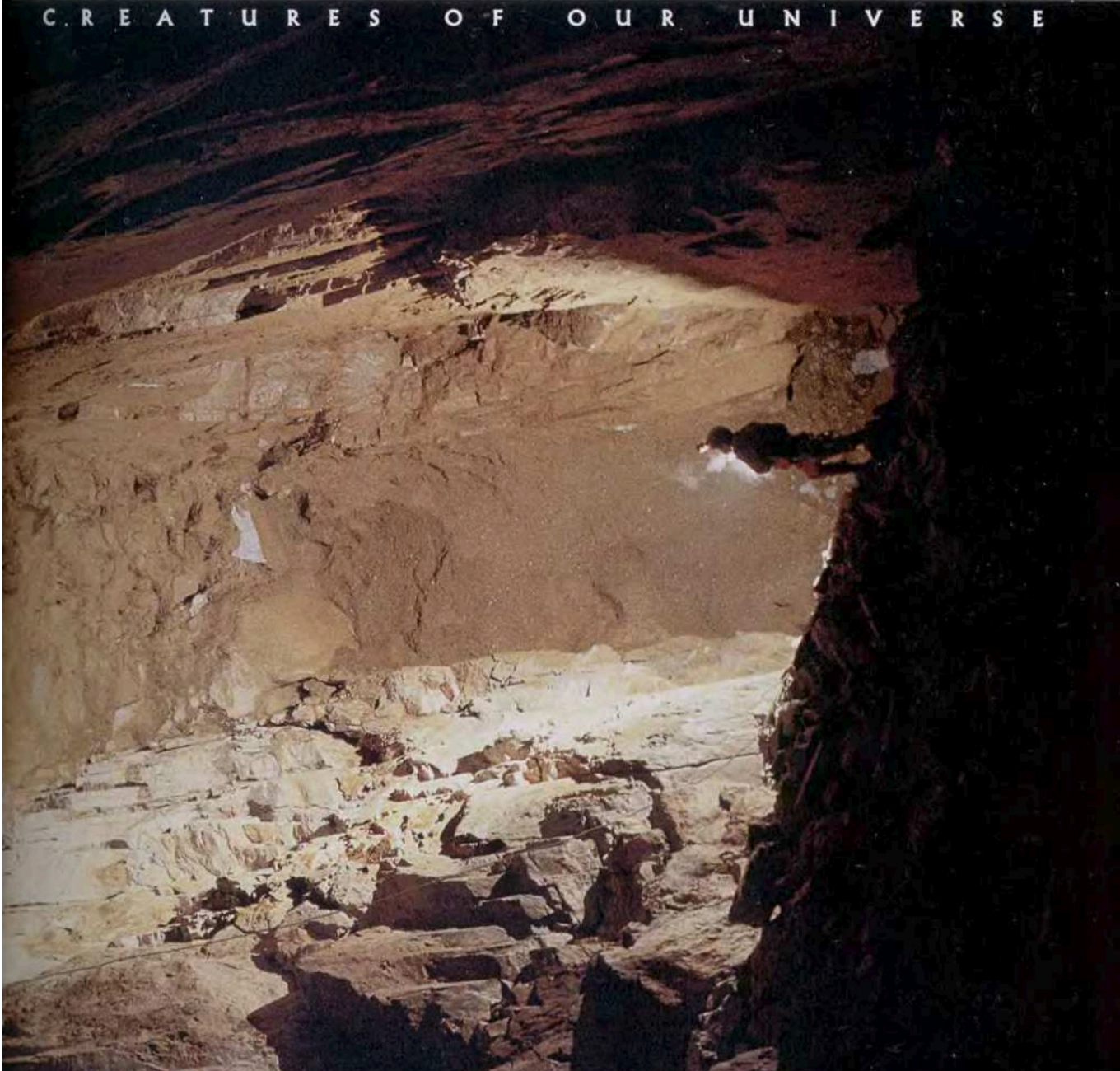
## Down in Mexico

*Grit and gear team up in quest for the deepest cave*

Here's what drives Bill Stone: a compulsion to leave his size 12 footprints in places no one has been tough enough or smart enough to reach before. The rawboned former astronaut candidate has always dreamed of walking on Martian plains and moon craters. But he's turned his attention from the heavens to a place deep in the Earth—Sistema Cheve, a cave system in the Sierra de Juárez of Oaxaca. Leading a team of cavers, Stone intends to negotiate Cheve's treacherous passages (above) and ultimately prove that it's the world's deepest system. By a long shot.

To do that, Stone has to find a connection—he's sure one must exist—between Cheve and a lower cave, Cueva de la Mano. If the link can be made, Stone will have explored a cave system that, as already shown by tracing the

BILL STONE





## GEOGRAPHICA



flow of underground water with dye, drops 8,356 feet from the mouth of Cheve to the bottom of Mano. The record holder, Krubera (Voronja) cave in the republic of Georgia (see *My Seven*, February 2004), has been explored to 5,610 feet by a competing group of cavers. And make no mistake, this is a competition, a “gentleman’s game,” as Stone calls it.

Dozens of elite cavers from around the world joined Stone at Cheve in 2003, when the team, rappelling through waterfalls (right), got down nearly 5,000 feet before being stopped by a passage clogged with fallen rock. They were back early this year in the dry season, when underground flooding is minimal, to seek a way around the blockage.

To improve the odds of success, Stone and his team relied on GPS receivers and satellite phones to help locate unexplored cave entrances, and on rock drills to aid in vertical climbs. Stone, an engineering Ph.D. who works with robots and spacecraft in his day job, modified the drills, making them



BILL STONE (BOTH)

lighter and with longer battery life. He has also improved rebreathers (below) that recycle divers’ breath for hours, facilitating exploration of watery passages. The equipment and the cavers have to be tough. Stone and his teammates endure mud, darkness, tight places, cold, and a sense of utter isolation. “You feel,” he says, “like you’re at

the absolute end of the world.”

With time running out in this year’s expedition, the team found a cave with wind drafting inward—an indication of depth. It could be the connecting route Stone is looking for. He hopes to return for a full-scale assault on it, but there are complications. In March a British team became trapped in a cave northeast of Mexico City, and for now the Mexican government has restricted caving. “A lot of diplomacy is going to have to take place before any more exploration does,” Stone says. —Chris Carroll



**CAVE RACE** Stone and his international team of explorers sent back regular dispatches and images from their eight-week expedition to the center of the Earth. Find them at [nationalgeographic.com/magazine/caverace](http://nationalgeographic.com/magazine/caverace).



## THE GEOGRAPHY OF EVERYDAY LIFE

## Name Calling Sparks Global Food Fight

The word Parmigiano means "from Parma," and when it comes to cheese in Europe, you can take that literally. In 2002 the European Court of Justice ruled only cheese makers in and around Parma, Italy, have rights to use the name Parmigiano Reggiano and its English translation, Parmesan. The cheese is just one item on a long list of several thousand foods, wines, spirits, and beers. Under European Union rules, the only wines that can bear the name Chablis are those bottled in the French region of that name, the only cheese sold as pecorino Toscano (below) has to be made in Tuscany, and, if a new global proposal is accepted, Oscar Mayer will have to find a new way to spell bologna.

At last September's meeting of the 146-nation World Trade Organization, the EU unveiled a shorter list of some 40 "geographical indications"—foods and libations named for or

## Origin of European food names

**Red** Beer, spirits, wine

**Orange** Cheese

**Green** Other food

European Union short list food names are italicized.

NG MAPS



associated with European areas. Under the EU-proposed global pact, geographic origin would trump existing trademarks, and many products that lack Old World provenance would have to be renamed. And the EU won't swallow half-baked labels like "Rioja-style" and "imitation Gorgonzola" either.

Sarah Thorn of the Grocery Manufacturers of America takes issue with the EU plan. "Why shouldn't we have rights to names brought over hundreds of years ago? Some are generic. It's too late to ask for them back."

The WTO, divided on the geographical indications proposal, has yet to make a decision. But exporters who want to sell their products in Europe must play by EU rules. So for European markets, food giant Kraft is selling its cheese—formerly-known-as-Parmesan as Pamesello Italiano. And California's Quady winery has shown that all the good names aren't taken. Its version of port wine is selling well in Europe as Starboard.

—Scott Elder



STEFANO SCATA/GETTY IMAGES



# My Seven



## Why We Must Go Back to the Moon

**Harrison H. Schmitt** *Geologist and Apollo 17 astronaut*

On December 14, 1972, Harrison "Jack" Schmitt finished 22 hours of rock and dust sampling (below) and climbed back into the lunar lander. No humans have landed on the moon since. Now Schmitt is one of the loudest voices calling for us to go back. There's something in the dust, says the Apollo missions' only scientist, that will make it worth the trip.

**1 Clean, abundant energy** When I sampled lunar dust in 1972, I had no idea it contained a future fusion-energy resource—helium 3, a rare (on Earth) helium isotope implanted by the solar wind. By-products of lunar helium 3 processing would include hydrogen, water, and oxygen—exactly what space settlers will need.

**2 A stepping-stone to Mars** A return to the moon to mine helium 3 will require heavy-lift rockets and will lead to fusion propulsion systems. I believe this combination ultimately will enable the exploration and settlement of Mars.

**3 Species survival** Humans need to find other places in the solar system to live. A permanent return to the moon will be as significant as our early ancestors' migration out of Africa.

**4 Expanded understanding of the universe** Lunar-based geology and astronomy will provide insights into our solar system, other galaxies, and perhaps other life-bearing planets.

**5 Save Earth from threats from space** Today we have nothing like the Apollo moon rockets. Only rockets big enough to reach the moon could

divert an asteroid—and help us avoid the fate of the dinosaurs.

**6 Education** Decades of interacting with students has convinced me that concepts taught in the context of space exploration stimulate minds in unique ways.

**7 Lunar tourism** Fly me to the moon? For the Apollo missions,

I estimate that it cost about \$26,000 per pound (in today's dollars) to send cargo to the moon. Successful mining could get the cost down to \$1,000 per pound—low enough to send a tourist for about \$200,000. A few travelers might be interested.

### WEBSITE EXCLUSIVE

See text and photos from Schmitt's 1973 *GEOGRAPHIC* article on the Apollo 17 mission at [nationalgeographic.com/magazine/0407](http://nationalgeographic.com/magazine/0407).



NASA (BOTH)



# Do It Yourself



## OLYMPIC NATIONAL PARK (SEE PAGE 56)

### GO THERE

## Extreme Olympic: Trek to Blue Glacier

Among Olympic's most spectacular attractions, glaciers also happen to be some of the most challenging for visitors to reach. Of the park's 60-some glaciers, the easiest to visit is Blue Glacier (below), which cascades down Mount Olympus, the highest point in Olympic. You can see Blue Glacier in the distance from Hurricane Ridge, not far from where the picture on pages 66-7 was taken. But only backpackers can get a close-up view—the terminus is a 17-mile hike from the Hoh Rain Forest Visitor Center. Seasoned mountaineers with crampons, rope, an ice ax, and experience with glaciers can even walk across it. Just don't do it alone.



BENJAMIN DRUMMOND

### PICKS

## 3 hikes

Experience Olympic's diverse habitats with these hikes suggested by photographer **Melissa Farlow:**

#### ■ Sams River Loop Trail

A three-mile hike through untouched rain forest. Go in the morning or evening to spot elk.

#### ■ Shi Shi Beach

Walk south along this hard-to-reach seashore to Point of the Arches to see sea stacks and tide pools.

#### ■ Obstruction Point

Choose one of two trails starting here to see snow-covered mountains, wind-swept trees, and alpine flowers. Closed in winter.





NATALIE FOBES, GETTY IMAGES

#### WHEN TO GO

## Watch Spawning Salmon

Olympic National Park's rivers, some of the last undisturbed salmon habitat in the Pacific Northwest, offer excellent opportunities to observe spawning Pacific salmon. And you don't have to worry about

fish-hungry grizzly bears—they don't live in the region.

Over 50 populations of coho, sockeye, chum, pink, and chinook salmon return from the Pacific Ocean to their natal Olympic rivers

and streams to spawn. Their spawning season varies, but fall is the best time to view them. In mid-October, bright red male summer cohos pair with females to fertilize eggs in gravel nests they build in the Sol Duc River (above). From November to January, sockeye salmon (left) spawn in Big Creek in the Quinault River Valley. And from November to December, fall chinook, the largest Pacific salmon—averaging 36 inches and 22 pounds—spawn in the Hoh River.

For more details about when and where to watch Pacific salmon, go to [nps.gov/olym/invspawn.htm](http://nps.gov/olym/invspawn.htm).

## Restoring Elwha River's Ecosystem

In 2007 demolition of the Elwha and Glines Canyon dams will begin, the first step in restoring Olympic's largest watershed after almost a century. Officials hope to restore access to more than 70 miles of stream habitat—enough to support over 300,000 sea-run fish, including descendants of the 100-pound chinook that once inhabited the river.

#### WEBSITE EXCLUSIVE

Get the goods on Olympic—the who, what, when, and how of traveling there—at [nationalgeographic.com/magazine/0407](http://nationalgeographic.com/magazine/0407).





MELISSA FARLOW; DOUG WILSON; CORBIS (BELOW)

#### GET INVOLVED

## Bust Plant Poachers



At most parks, rangers worry about protecting resources from encroaching development and tourist hordes. At Olympic, they're more concerned about plant thieves. Poachers have been known to take everything from mosses to old-growth cedars here. The top illegal crop is salal (left), a shrub whose stalks are popular

in Europe as filler in floral arrangements. "We recently apprehended pickers with about a thousand stalks of salal," says special agent Glen Melville. If you see signs of poachers, such as rubber bands (used to secure bunches of stalks) littering the side of the road, notify a ranger. Pickers often return to the same spot.

#### GET MORE

To learn more about a subject covered in this issue, try these National Geographic Society products and services. Call 1-888-225-5647 or log on to [nationalgeographic.com](http://nationalgeographic.com) for more information.



#### FROM THE SOCIETY

- **Olympic National Park Trails Illustrated Map.** A tear-resistant topographic map to help you find your way—and it's waterproof (essential for frequent rains). Map highlights hiking trails, fishing holes, campgrounds, and other places of interest (\$9.95).
- **Guide to the National Parks of the United States.** Learn more about Olympic. The book includes suggested drives for sampling the park's diverse ecosystems (\$24.95).
- **TOPO! Washington** CD-ROM set. Seamless statewide coverage allows you to design and print your own USGS topo map centered on any spot in the Olympic region, then customize it with routes, Web links, photos, and optional 3-D relief (\$99.95).



# Behind the SCENES

AT THE NATIONAL GEOGRAPHIC SOCIETY



ROBERT CAPUTO

## Losing Gentle Yoda

*Black bear cub raised by human is killed*

Orphaned siblings Yoda (above, at right) and Houdini were raised by a human—Ben Kilham, the Mother Bear Man of our March 2002 article. By imitating a

mother bear, Ben taught eight orphaned cubs skills they need to survive in the New Hampshire wild. In raising, collaring, and tracking the cubs, Ben gleaned insights into bear behavior. Last

fall, a hunter shot Yoda next to her den—despite requests not to hunt bears in the area. “Yoda was a very gentle animal,” Ben says, adding that part of him wishes he didn’t have to track his rehab bears. “Then you can think they live forever.” Yoda lives on in her two offspring: Norry, whose movements Ben plans to start tracking this year, and Norris.

## Grand Guide

*NG center aids visitors*

Ninety percent of the Grand Canyon’s visitors reach the 1.2-million-acre national park via the South Rim. To help focus those visits, a new National Geographic visitors center opened this spring in Tusayan, Arizona, a mile and

a half from the canyon’s South Rim entrance. Adjoining the Destination Cinema theater—where the IMAX film *Grand Canyon: The Hidden Secrets* is shown on a seven-story screen—the center offers maps with itineraries, tips on picture taking, and a gallery of canyon images. Visitors can also pay canyon entrance fees there and avoid lines at the park gate.



RAYMOND GEHMAN



## Habitat Heroes Start Young

*Kids tending to the Earth*

**S**coop by scoop, students at Harriet Tubman Elementary School in Washington, D.C., have transformed their school's courtyard (right). The nine- to twelve-year-olds planted native shrubs and trees and installed bat and bird houses to create a healthy, animal-friendly habitat—a feat certified by the National Wildlife Federation.

The Tubman kids are among our 30,000 Habitat Heroes, students across the U.S., Canada, and Mexico participating in the Society's Geography Action! program on habitats. Since September these heroes have also rescued ailing cactuses, created butterfly gardens, and



GWENDOLYN FAULKNER

restored aquatic gardens. With help from our Education Foundation, their teachers learned how to incorporate these and other environmental projects into the classroom curriculum.

Beginning in September, Geography Action! will enlist students in a new challenge—preserving world cultures. For more details, go to [nationalgeographic.com/geographyaction](http://nationalgeographic.com/geographyaction).

## Photographer Scores at Animal Name Game

Photographer and entomologist Mark Moffett, who reports on wind scorpions in this issue (see page 94), has lent his name to yet another new species. On an expedition to the remote *tepuis*, or mesas, of eastern Venezuela, he and colleagues César Barrio and Charles Brewer discovered a species of rocket frog. "It's a little



MARK W. MOFFETT

brown job," says Mark of the amphibian that will soon bear a scientific version of his name—the third *moffetti*. The first, a species of beetle he co-discovered in Peru

in 1976, when he was 18, became *Notiobia moffetti*. Years later Mark found a new ant species while shooting the leafcutter ant story (see NATIONAL GEOGRAPHIC July 1995), and his mentor, Harvard biologist E. O. Wilson, christened it *Pheidole moffetti*. But Mark's legacy isn't confined to science. He helped novelist Amy Tan dream up a plant for her upcoming book, and she named it after him. Says Mark, "I guess I'm on a hot run right now."

### GET MORE

### CAQUETÁ, COLOMBIA (PAGE 34)

To learn more about a subject covered in this issue, try these National Geographic Society products and services. Call 1-888-225-5647 or log on to [nationalgeographic.com](http://nationalgeographic.com) for more information.



- **The War Next Door** on National Geographic's Ultimate Explorer on MSNBC, Sunday, July 18, 9 p.m. ET/6 p.m. PT. Host Lisa Ling goes to the front lines of Colombia's drug war, interviewing Colombian President Álvaro Uribe, coca farmers, and even a former assassin.
- **"Kidnapped in the Gap,"** *National Geographic Adventure*, June/July 2003. Relive the terror with journalist Robert Young Pelton as he describes how he and two companions were kidnapped by a shadowy Colombian military group during a trek between Panama and Colombia.
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# Who Knew?

## ENTOMOLOGY

### Golden Years

*Cockroaches suffer from creaky joints too*

**Y**ou've probably never pondered the aging process of the cockroach. You've never looked at a cockroach and thought: That one's a little long in the tooth. Or: That one must be looking for the early bird special. No, you've thought: Where'd I put the Raid?

But a creature we find repulsive in ordinary life may help us solve some of the mysteries of human aging. Is getting old primarily a mechanical problem, a decrepitude in joints and muscles? Or is it a bigger problem located somewhere in our worn-out brains?

Roaches are good research subjects because they're big by insect standards, which makes it easy to study their relatively simple nervous systems. They don't require a lot of care either. You can chuck them in a plastic garbage bin, slather Vaseline around the rim to discourage escapes, toss them some dog food once in a while, and everyone's happy.

There are reasons roaches have been around for more than 300 million years. One is that they're fabulous at running

away from danger. Although even the swiftest roaches only go three miles an hour, that's all the velocity they need to sprint to the nearest crack in the baseboard.

Christopher Comer, a neuroscientist at the University of Illinois at Chicago, studies roach escape behavior. "When you puff wind on a cockroach, it's off and running in 50 milliseconds," Comer says. "If you smack a roach's antenna abruptly, it can turn and run in 15 to 20 milliseconds. Quicker than the blink of an eye." Compare that with a human, whose brain usually needs about 200 milliseconds (a fifth of a second) to respond to a stimulus.

But roaches, like all of us, get old. Angela Ridgel of Case Western Reserve University recently shot high-speed video images (125 frames per second) as roaches ran down a little hallway with a see-through floor. Ridgel discovered that about 60 weeks after its final molting, a roach starts to trip. The front legs literally snag on the middle legs. Old roaches also begin to slip while walking uphill.

Studies of escape behavior by Comer and Ridgel show another sign of roach senescence:

When they get older, roaches react less reliably to being touched or hit by a puff of wind. Sometimes they run; sometimes they just stand there.

In addition to aiding in the study of human aging, roach research can help the space program, Comer says. He points out that the roach escape

mechanism has an admirable redundancy. The hairs on a roach's cerci, two rear appendages extending from the abdomen, are tied into one sensory system, but the antennae are tied into another. So the roach can operate with one system deactivated. In some experiments researchers remove the insect's head, and it still manages to get around.

"Suppose you wanted to build controlling circuitry for a rover on Mars," Comer says. "You might want to base the design on the kind of dual circuitry that insects use. With a simple nervous system roaches achieve rather sophisticated control."

And if the rover breaks down, the engineers could blame it on a bug in the system.

—Joel Achenbach

WASHINGTON POST STAFF WRITER

### Cockroach Sentry System

How is it that cockroaches, which run about three miles an hour, manage to zoom out of sight just as you're poised to squash them? It's because tiny hairs on their cerci sense changes in the air. A boot beginning to descend creates low-frequency wind different from normal air movements; as soon as the insect detects the suspicious wind, it runs.

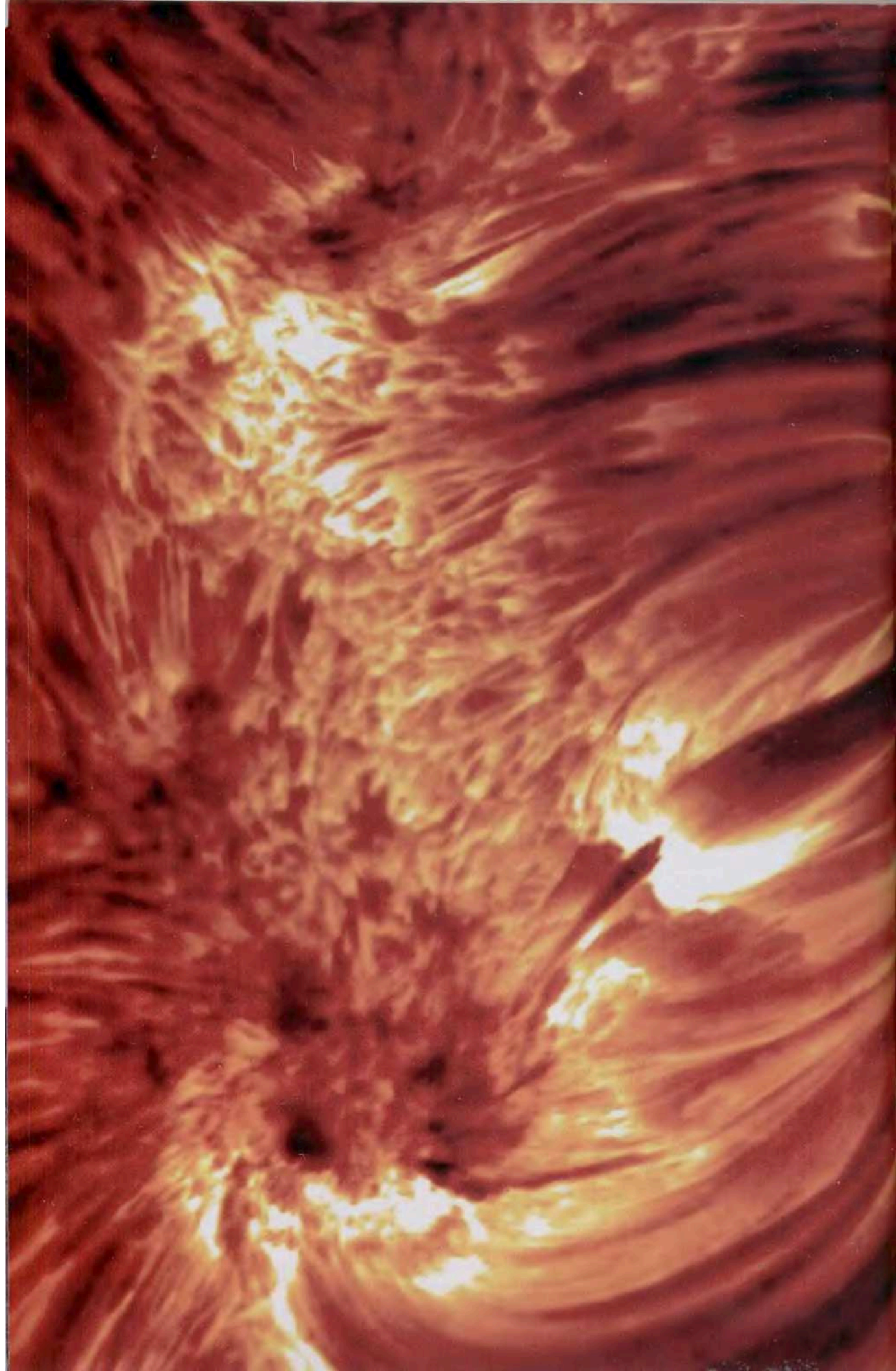
You can outsmart a cockroach's sentry system by aiming a vacuum cleaner nozzle at it. The roach perceives the suction as wind coming from the opposite direction, and will flee into the nozzle.

—Heidi Schultz

**WEBSITE EXCLUSIVE** For more on insect aging, and for links to Joel Achenbach's work, go to Resources at [nationalgeographic.com/magazine/0407](http://nationalgeographic.com/magazine/0407).









the

Living With a Stormy Star

sun





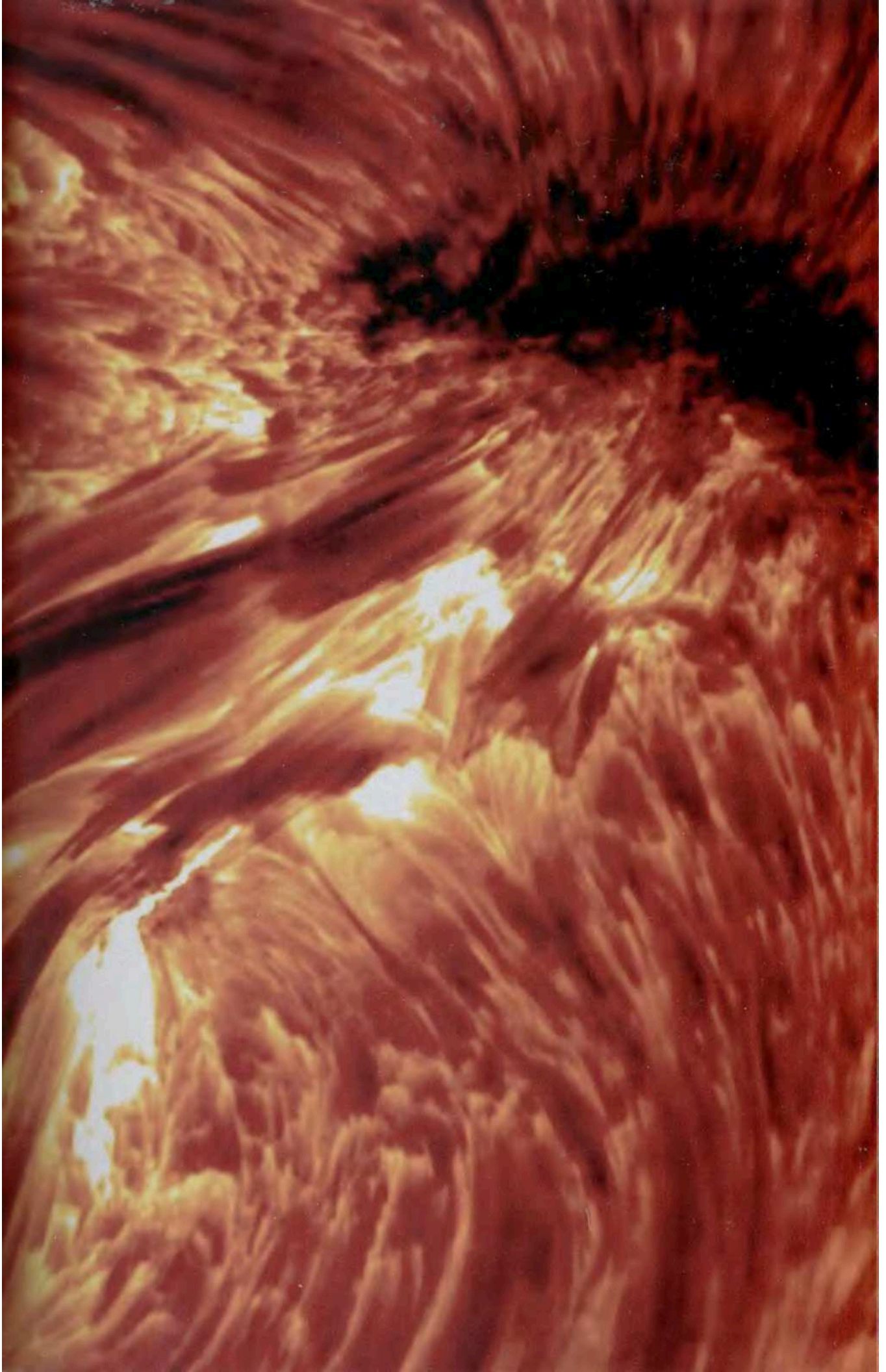
Only now are we truly beginning to understand the **thermonuclear reactor** we call the **Sun**.

The dark heart of a sunspot—the diameter of Earth—and the swirling formation around it have never been photographed so clearly. Such images from the new Swedish Solar Telescope on the Canary Island of La Palma add to groundbreaking data from terrestrial and space observatories that are making this the golden age of solar science. There's urgency to the quest: Even as our local star makes life on Earth possible, its outbursts can also wreak havoc.

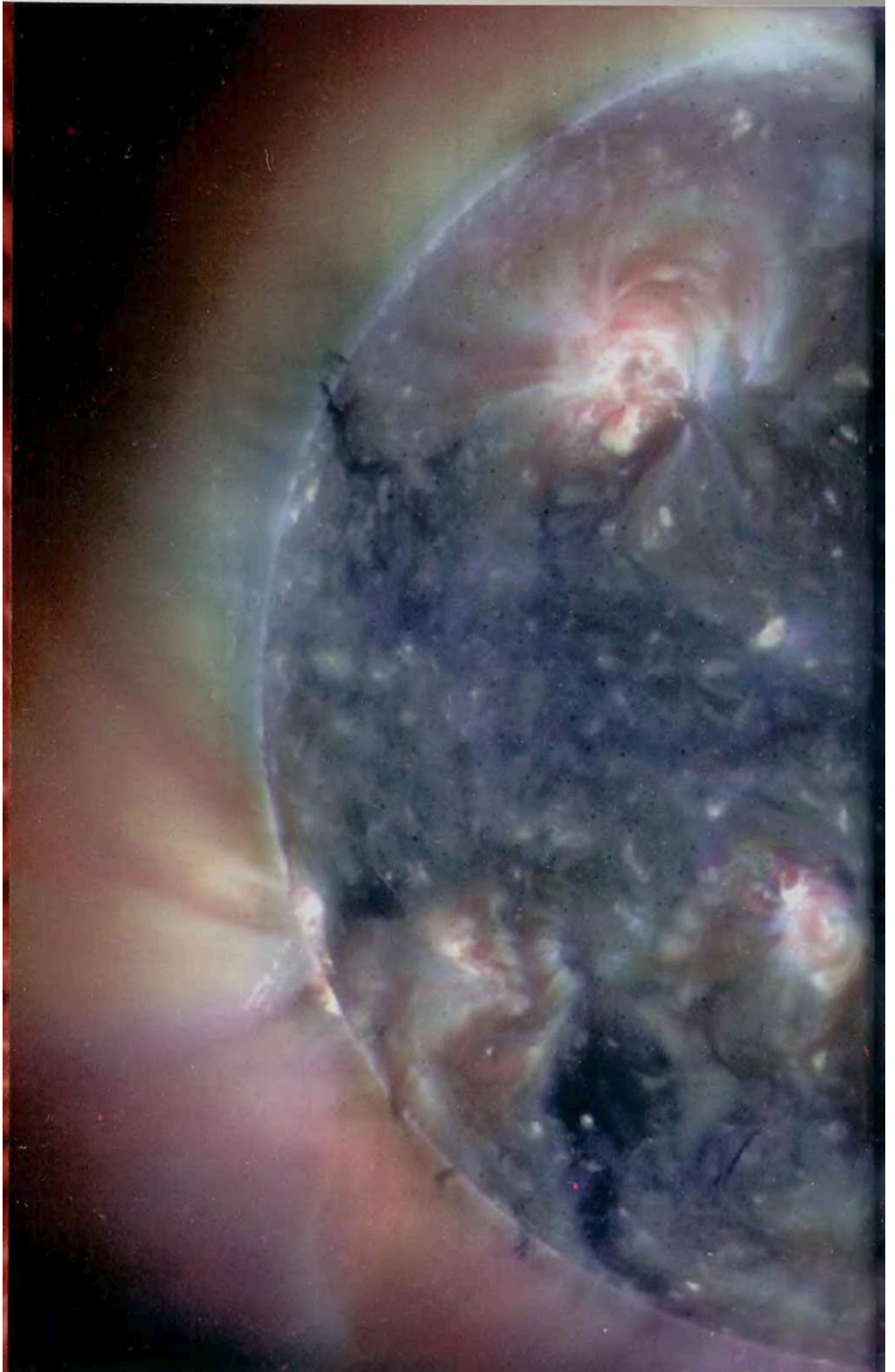
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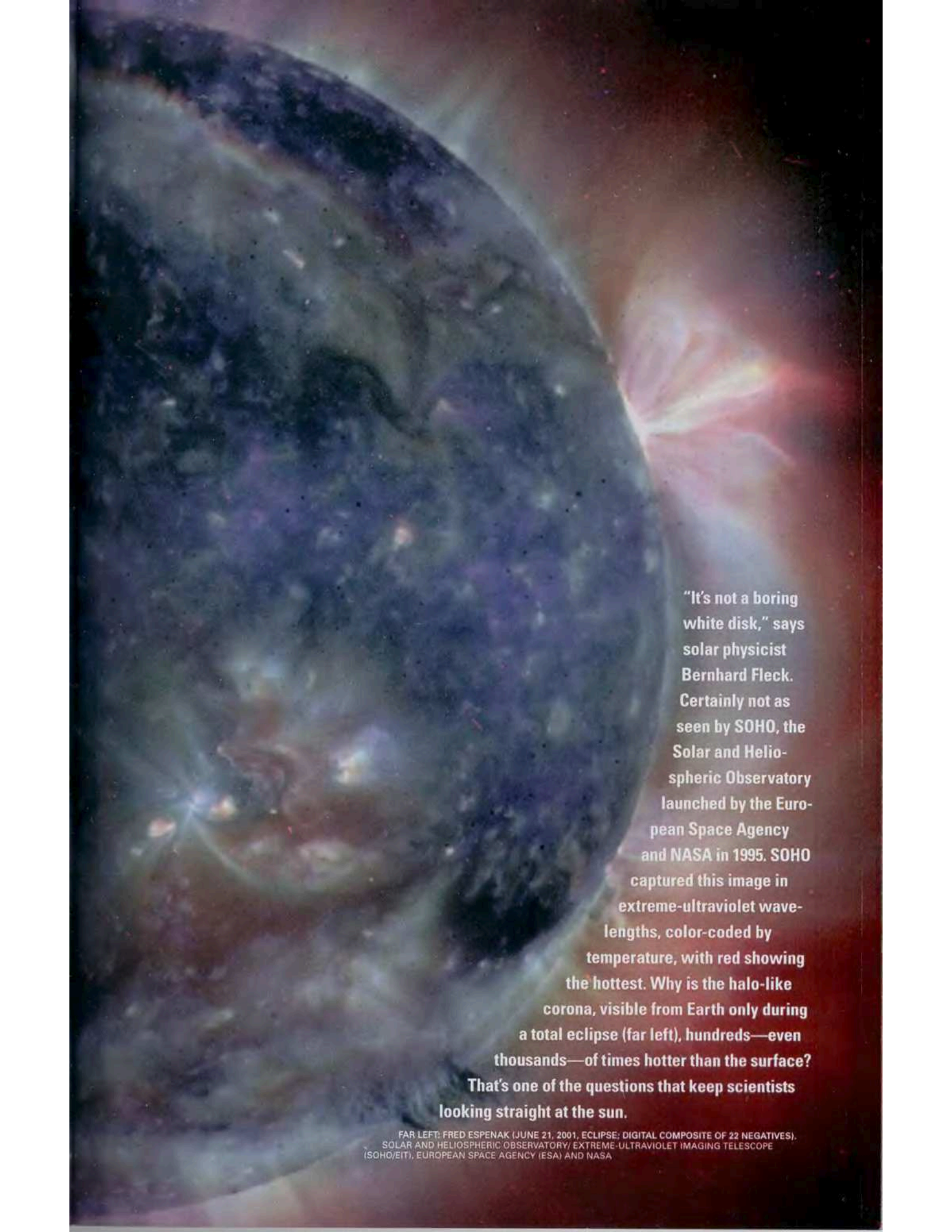












**"It's not a boring white disk," says solar physicist Bernhard Fleck. Certainly not as seen by SOHO, the Solar and Heliospheric Observatory launched by the European Space Agency and NASA in 1995. SOHO captured this image in extreme-ultraviolet wavelengths, color-coded by temperature, with red showing the hottest. Why is the halo-like corona, visible from Earth only during a total eclipse (far left), hundreds—even thousands—of times hotter than the surface?**

**That's one of the questions that keep scientists looking straight at the sun.**

FAR LEFT: FRED ESPENAK (JUNE 21, 2001, ECLIPSE; DIGITAL COMPOSITE OF 22 NEGATIVES), SOLAR AND HELIOSPHERIC OBSERVATORY/ EXTREME-ULTRAVIOLET IMAGING TELESCOPE (SOHO/EIT), EUROPEAN SPACE AGENCY (ESA) AND NASA










**Magnetism made visible:** That describes virtually every feature on the sun, from sunspots to soaring structures called loops. Loops easily reach the height of ten Earths (see icon for size comparison). Energy generated by the dynamics of smaller loops is likely the source of the corona's mysterious heat.

The superheated gases that form the sun, mainly hydrogen and helium, exist in an electrified state called plasma. Below the surface, plasma can push and drag magnetic field lines. But when lines are strong enough to arc out, wildly conductive plasma follows.

MARKUS J. ASCHWANDEN, LOCKHEED MARTIN SOLAR AND ASTROPHYSICS LABORATORY (LMSAL), RECORDED IN EXTREME ULTRAVIOLET FROM NASA'S TRANSITION REGION AND CORONAL EXPLORER (TRACE) SATELLITE





**Mercury aligned with the Earth and the sun on May 7, 2003 (right), as it does 12 or 13 times a century. Far rarer: Venus could be seen crossing the sun last month for the first time since 1882. The transit of Venus in 1769 found observers around the globe—including Capt. James Cook in Tahiti—taking measurements in a joint effort to figure the distance from Earth to the sun. They were off by only two million miles. It's 93 million miles away, on average, and its light makes the trip in about eight minutes.**

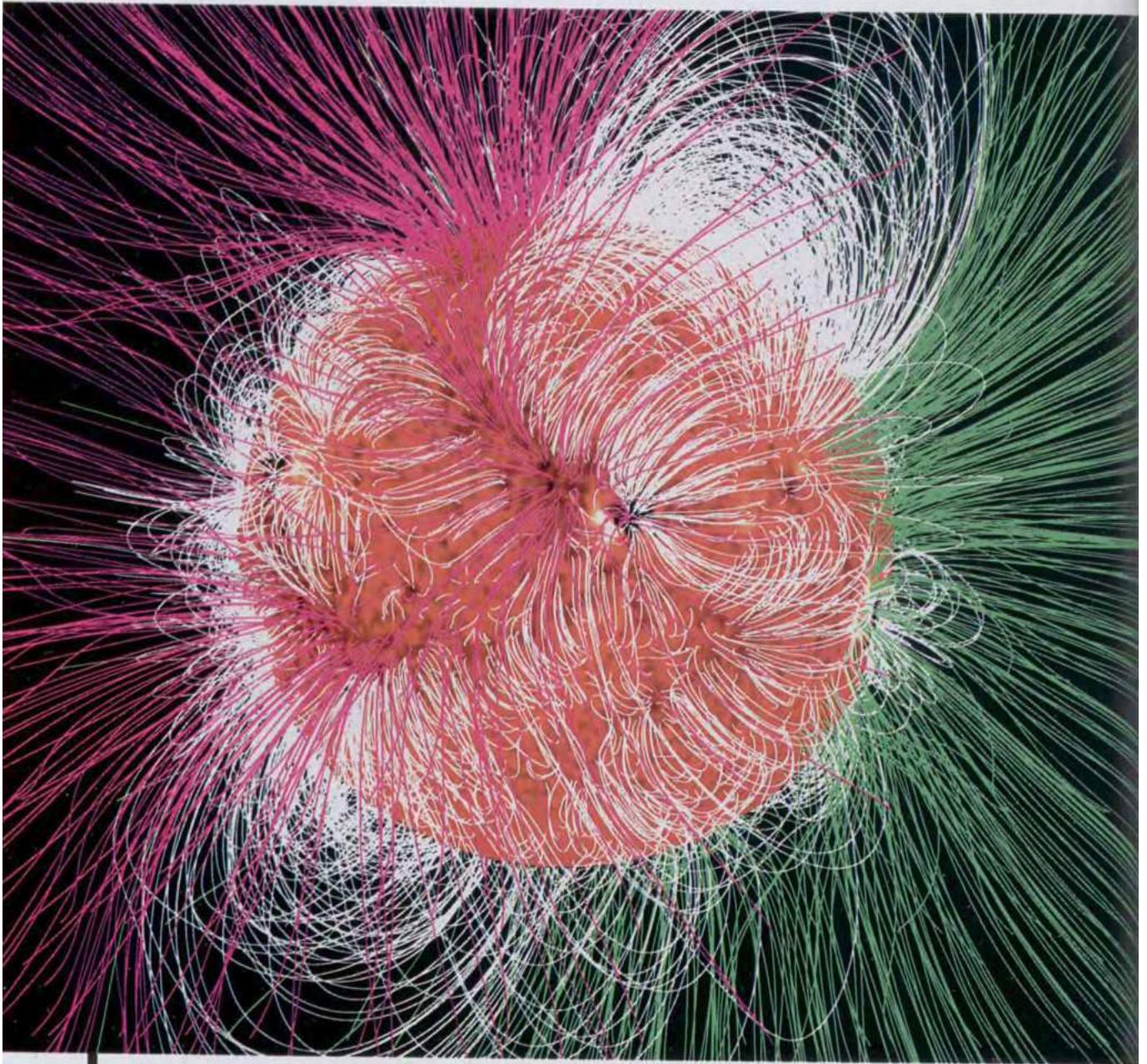
MATS LÖFDAHL AND PETER DETTORI, INSTITUTE FOR SOLAR PHYSICS OF THE ROYAL SWEDISH ACADEMY OF SCIENCES (ISP/RSAS). SWEDISH 1-METER SOLAR TELESCOPE

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Our star has been slow to give up its **secrets**. To study the sun is to enter a realm that is **surpassingly weird**.



BY CURT SUPLEE

**T**hey call it “good seeing.” Squinting up into the luminous blue morning 8,000 feet above the Atlantic off the west coast of Africa, it’s not hard to see why.

To astronomers good seeing means the air will permit a sharp and stable image of celestial objects. And indeed, it’s almost surreal, the sapphire clarity over La Palma, one of the westernmost Canary Islands.

“Hold your arm out until your thumb just barely covers the sun,” says Göran Scharmer, director of the Royal Swedish Academy of Sciences’ Institute for Solar Physics. “When it’s dark blue right up to the edge of your thumb, it’s going to be a coronal sky.”

Coronal sky itself doesn’t guarantee good seeing, but it’s one sign of a calm, dust-free atmosphere. That’s why Scharmer and his team are here atop the rim of an ancient caldera, half a mile above the cloud deck, continuing a quest as old as man: studying the fire in the sky.

It has been burning for 4.6 billion years, even before there was an Earth to bask in its all-sustaining glow. Yet it is only in the past two decades that scientists truly have begun to understand the thermonuclear reactor we call the sun.

By big-time galactic standards, our star is quite undistinguished. Sure, it’s so huge that a million Earths would fit comfortably inside. And it’s so dense that the sunbeams you see today began their journey from the center of the sun before the last ice age, taking hundreds of thousands of years to elbow their way out to the glowing photosphere before making the 8-minute, 93-million-mile trip across space to your eyes.

**THE SUN’S EVER CHANGING MAGNETIC FIELD** looked like this (left) on January 14 this year. Along open, colored lines plasma streams away, filling the solar system with what’s called solar wind. It blows fastest from dark, low-magnetic areas seen that day (above).

COMPUTER SIMULATION: KAREL SCHRIJVER AND MARC DIROSA, LMSAL (LEFT); SOHO/EIT, ESA AND NASA

Yet the sun falls into the general stellar category of yellow runts called type G, a species so monotonously common that there are billions of them in the Milky Way alone. And it appears to be remarkably stable so far, with an energy output that varies no more than one-tenth of one percent over the course of a decade, and not much more over centuries.

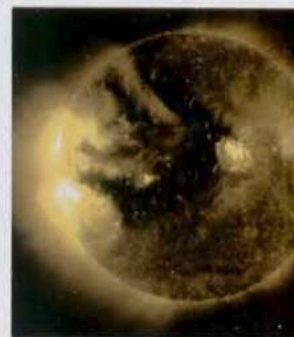
But nothing else in the universe—save only our planet itself—is more immediately important to us. The sun is the origin of virtually all the energy that sustains life, the source of our weather, arbiter of our climate, and, of course, our closest connection to the processes that populate galaxies and power the cosmos.

“The sun is the Rosetta stone of astrophysics,” says Scharmer, whose observations with the Swedish 1-meter Solar Telescope on La Palma keep setting world records for high resolution. “But it is a stone that we haven’t been able to decrypt entirely.”

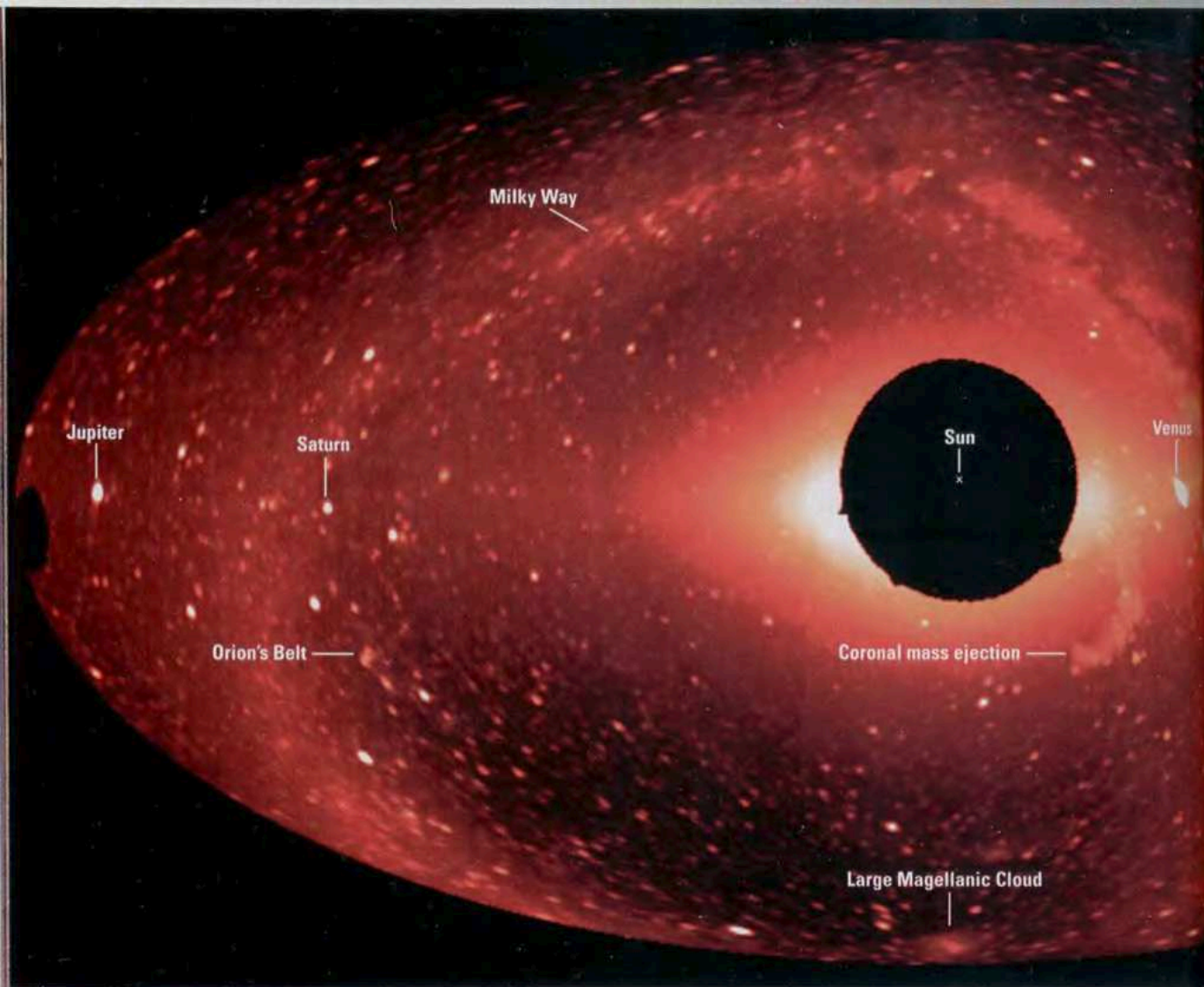
Even today, four centuries after Galileo and others stunned Europe by revealing that a spatter of spots moved across the solar surface, many of the most profound aspects of our local star remain shadowed in mystery. Now scientists are on the cusp of finding answers, thanks to a surge of international interest over the past 20 years—and to advances in computer modeling and new, high-tech instruments on the ground and in space that can monitor subtle aspects of solar behavior that were previously unrecognizable, and sometimes unimaginable.

“Before, it was solar dermatology,” says Scharmer. “Now it’s really astrophysics.”

But much finer telescopic resolution is still needed. Many scientists believe that some fundamental solar structures are only a few miles wide. The best resolution with the Swedish telescope is 50 miles, so the team has been furiously upgrading its instruments. Ditto for investigators at some of the scores of terrestrial facilities from Sunspot, New Mexico, to the mountain







## "The sun is the Rosetta stone of astrophysics,

summits of Maui and the forbidding Siberian outback. Off the planet there are nearly a dozen major space-based observatories—almost all of them launched since the mid-1990s.

In addition there are new initiatives to understand and forecast space weather, the effects created by the billions of tons of plasma that can erupt from the sun and cause magneto-electrical squalls throughout the solar system.

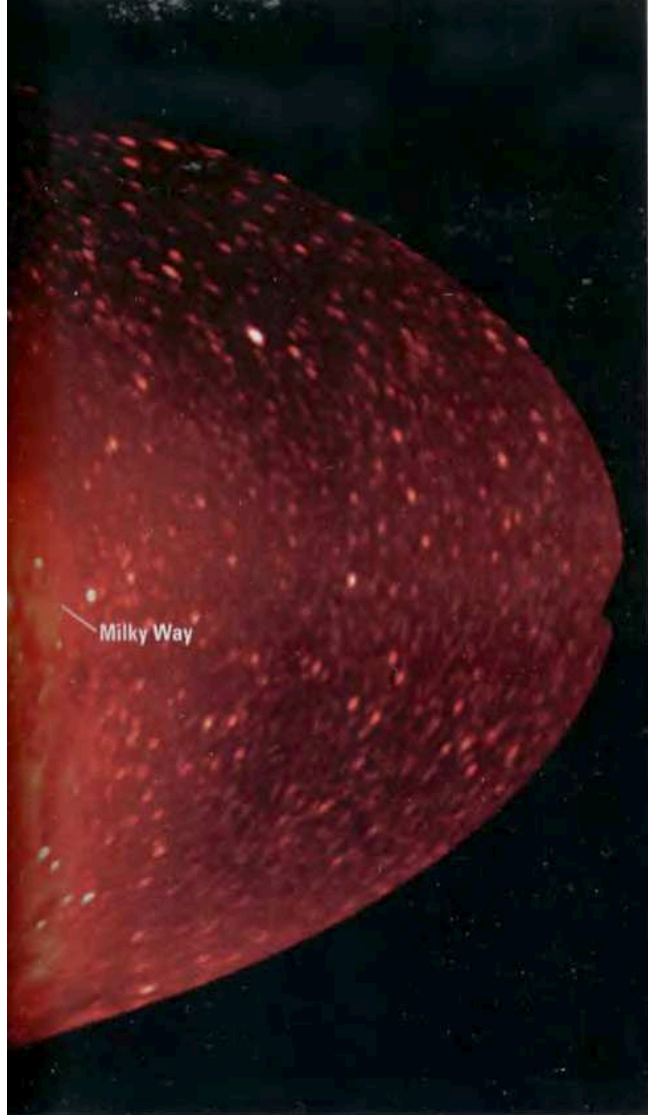
"In space weather we're about where terrestrial weather forecasters were 40 years ago," says Timothy Killeen, director of the National Center for Atmospheric Research (NCAR) in Boulder, Colorado, and a principal investigator at the new Center for Integrated Space Weather Modeling at Boston University. "One of the most important things that we need is end-to-end modeling—a comprehensive view of what happens all the

way from the interior of the sun to Earth's upper atmosphere." With today's observational and computing power, Killeen says, "we've got the resources to make significant progress within just a few years."

For those who operate sensitive satellite broadcast and communications systems, the global positioning system, military spacecraft, and sundry systems critical to modern life, it can't be soon enough.

Although nearly everything that happens in and on the sun affects our planet, two kinds of explosive solar events impact Earthlings most severely. One is a solar flare, in which a small area above the solar surface suddenly roars to tens of millions of degrees, throwing off a surge of radiation that can cause communications blackouts, disable satellites, or,





lights were seen as far south as the Mediterranean, but little damage was done. By contrast, in 1989, when a fierce CME struck the Earth, it blew out HydroQuebec's power grid, leaving almost seven million people without electricity, and a multimillion-dollar damage bill.

Not surprisingly, locating the causes of such events is a top priority among researchers. But our star has been slow to give up its secrets, and no wonder: To study the sun is to enter a realm that is surpassingly weird.

Most of the Earth is solid. By contrast, all of the sun is gas: about 70 percent hydrogen, 28 percent helium, and 2 percent heavier elements.

**LOOKING OUT FROM EARTH ORBIT, a new satellite called Coriolis uses its Solar Mass Ejection Imager to build a wraparound view of the cosmic neighborhood. This satellite is a watchdog: It aims to detect and track potentially harmful eruptions of plasma called coronal mass ejections, this one spotted in May 2003.**

AIR FORCE RESEARCH LABORATORY, HANSCOM AFB, MASSACHUSETTS. COMPOSITE ALL-SKY IMAGE; CORONAL MASS EJECTION IMAGE GREATLY BRIGHTENED AND SUPERIMPOSED

but we haven't been able to decrypt it entirely."

—Göran Scharmer, Institute for Solar Physics

theoretically, kill a spacewalking astronaut.

The other event is a coronal mass ejection (CME), in which billions of tons of charged particles escape from the sun's halo, the corona, at millions of miles an hour. When these behemoth clouds slam into Earth's protective magnetosphere, they squash the magnetic field lines and dump trillions of watts of power into Earth's upper atmosphere. This can overload power lines, causing massive blackouts, and destroy delicate instruments on anything in Earth orbit.

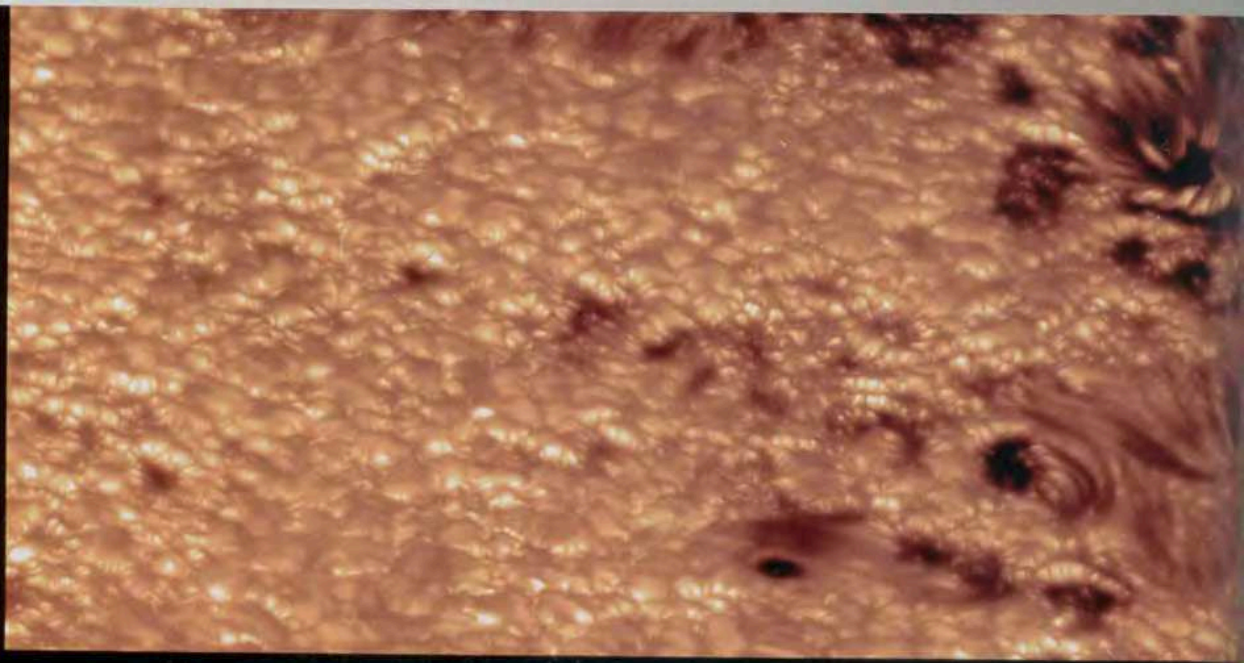
Often flares and CMEs occur together, as was the case last October when the fourth most powerful flare ever observed exploded. Back-to-back CMEs then smacked the planet. Thanks to modern detection equipment, we had enough warning to take preventive action. The atmosphere was so electrically charged that the northern

The outer visible layer is called the photosphere. But in fact, the sun has no "surface," and its atmosphere extends all the way to Earth and beyond, thinning out as it goes.

Moreover, the sun is a madhouse of electromagnetic activity. On Earth very few materials are good conductors of electricity. But in the sun almost everything is electrically conductive because there aren't many intact neutral atoms. The overwhelming thermal and radiation energies excite electrons to the point at which they pop off their atoms, creating a seething stew of positively charged nuclei and free negative electrons—a gaseous mix called plasma that can carry current as easily as copper wire.

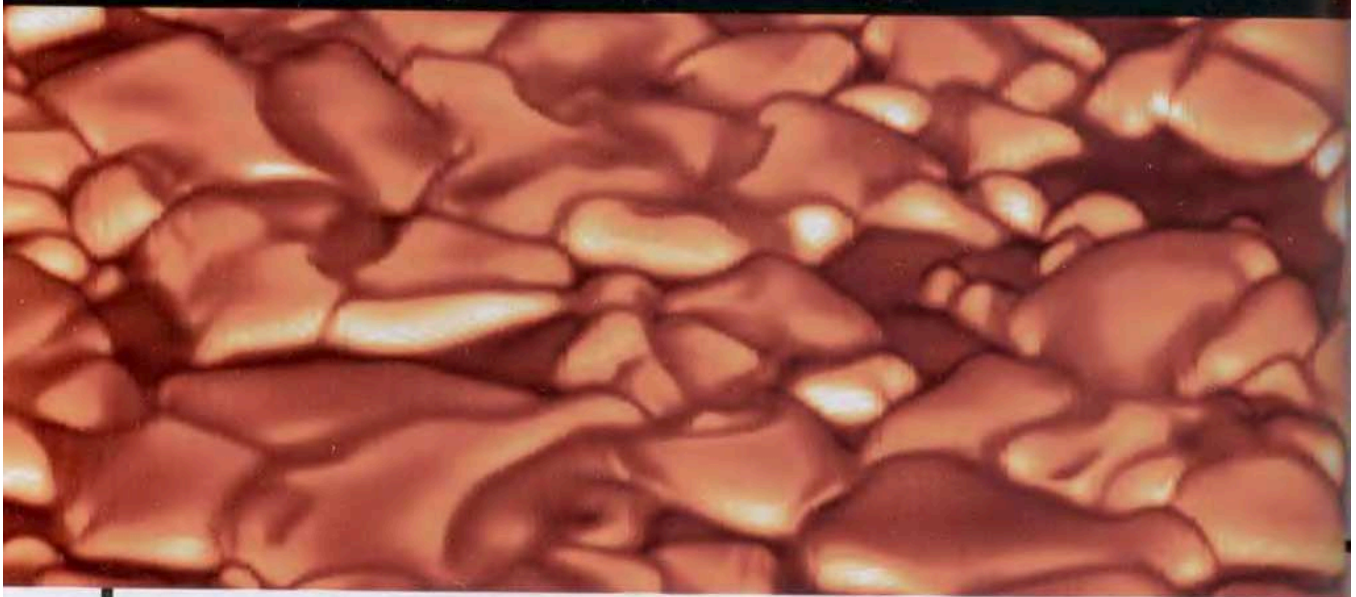
Like any electrically charged object, plasma produces magnetic fields when it moves. As those fields shift, they induce more currents to flow,





**BUBBLES THE SIZE OF TEXAS** cover the sun's face (above), as seen by the Swedish Solar Telescope, which has made the first images sharp enough to reveal the structures in three dimensions. Called granules, the short-lived cells of plasma carry heat to the surface through convection, the same way water boils in a pot. The rise and fall of granules creates sound waves, which cause the sun to throb like a drum every five minutes. "Now we can better imagine the turbulent nature of the canyons between granules [art, right]," says solar physicist Tom Berger. The telescope observations and corresponding computer models (below) confirm earlier theories: Bright spots called faculae form when magnetism builds up in the canyons. Faculae abound near highly magnetic sunspots, which is why the sun is brightest when dark sunspots (above, at top right) are most numerous. "But faculae are not entirely understood," says Berger. "The sun's surface looks more complex than ever."

GÖRAN SCHARMER AND MATS LÖFDAHL, ISP/RSAS (ABOVE); ÅKE NORDLUND, NIELS BOHR INSTITUTE FOR ASTRONOMY, PHYSICS, AND GEOPHYSICS AND ROBERT STEIN, MICHIGAN STATE UNIVERSITY (BELOW); ART BY KENNETH EDWARD



It's been **burning** for 4.6 billion years, even before



which in turn produce more fields. This tangle of plasma and magnetic and electrical effects determines the forms of nearly everything in or above the sun, such as the bright coronal loops and the dark areas we call sunspots.

“Everything we see as solar activity,” says Stephen Keil, director of the National Science Foundation’s National Solar Observatory, a consortium of facilities in New Mexico and Arizona, with telescopes around the world, “is a magnetic field being acted on by plasma and vice versa.” Both are forever in motion.

The source of this energy is nuclear fusion. Like all stars, the sun formed when local gas and

the solar core is so dense that a single photon, the fundamental unit of light, can’t go even a fraction of a millimeter before banging into some subatomic particle, where it is scattered or absorbed and re-emitted. As a result, it can take hundreds of thousands of years for a photon to ricochet its way nearly half a million miles to the sun’s surface. By that time, it has shed so much energy that most of it emerges as the fairly puny radiation we call visible light.

It took decades to comprehend the physics of this process, which was ridiculed as outlandish in the 1920s when it was first suggested by the great British astronomer Sir Arthur Eddington and



dust drifted together, drawn by gravity, swirling into a sphere. As the mass became larger and larger, hydrogen at the center was crushed by the gigantic pressure, finally sparking a fusion reaction in which hydrogen nuclei come together in a multistep reaction to create helium. The resulting nuclei are just slightly less massive than the component hydrogen nuclei that formed them. The difference is converted to energy according to Einstein’s famous  $E=mc^2$ .

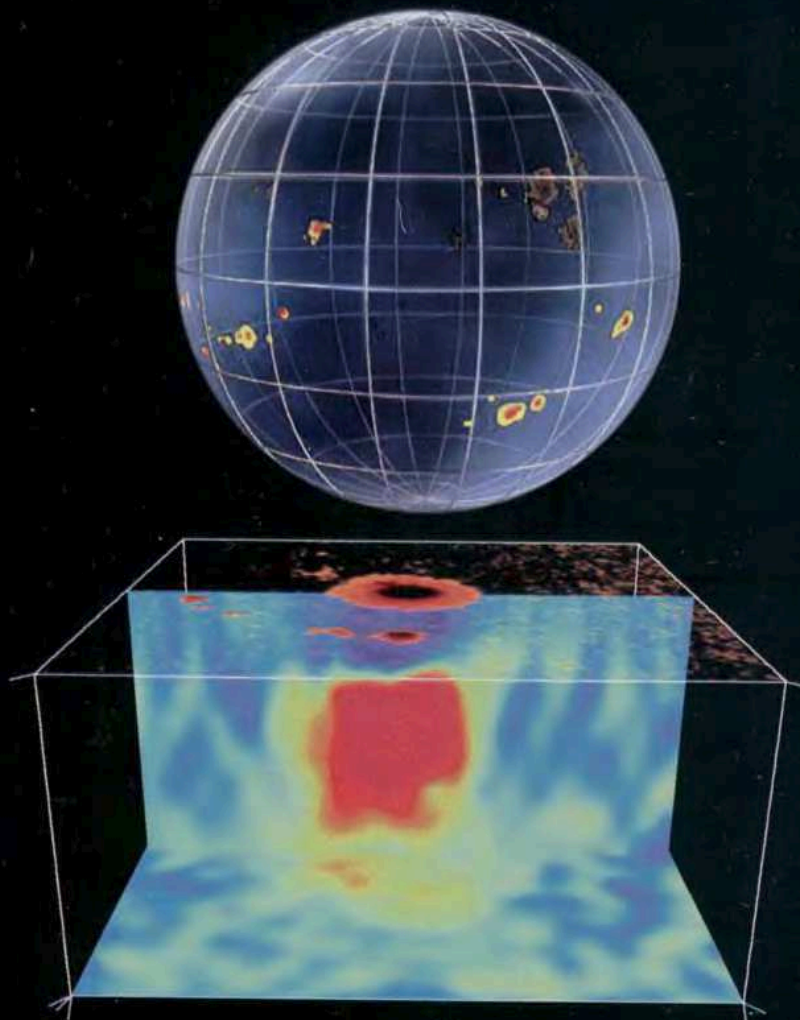
Much of that energy is carried away as light in the form of gamma rays—the most energetic wavelength of electromagnetic radiation. But

others, who were convinced that the source of the sun’s power was some subatomic phenomenon requiring enormous heat. “We do not argue with the critic who urges that the stars are not hot enough for this process,” Eddington wrote in 1926. “We tell him to go and find a hotter place.”

By the 1950s, however, the fusion model had been convincingly verified, except for one infuriating mystery: the output of wraithlike subatomic particles called neutrinos that are produced in the fusion process. Despite decades of painstaking searches, researchers were able to detect only a third of the neutrinos that

there was an Earth to bask in its glow.





**SOLAR SONOGRAM:** Scientists can now see beneath the blazing surface with a technique called helioseismology. Doppler instruments on SOHO and on Earth measure sound waves moving through the sun. Changes in wave speed reveal inner structures. Helioseismology confirms that the magnetism of a sunspot (left bottom) keeps the plasma below cool (purple) and blocks hot rising plasma (red). It can even detect sunspots on the other side of the sun (left top). Critically, helioseismology shows that the convection zone and the deeper radiation zone rotate at different speeds, generating the main magnetic field. Another stunner: Data gathered from

“Nobody dreamed there would be the possibility

theory predicts should strike the Earth every day. Finally, three years ago, a remarkable international effort involving facilities in Japan and Canada solved the problem by demonstrating that the “missing” neutrinos had mutated into different types that had not been detectable until the latest instruments became available. Solar physicists are still rejoicing.

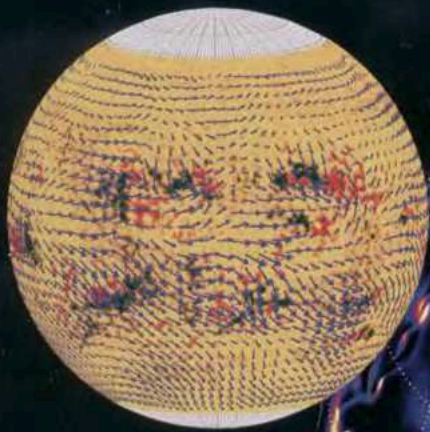
**E**lation indeed is the feeling in the science community for what today’s explorations are adding to our knowledge of the sun. Peter Gilman, a veteran sun researcher with NCAR’s High Altitude Observatory, sums it up: “This is the golden age of solar science.”

As the neutrino resolution illustrates, it’s an international affair. The workhorse of the solar space fleet, for instance, is the Solar and Heliospheric Observatory (SOHO), a satellite run

jointly by the European Space Agency and NASA. Launched in 1995, its arsenal of instruments has contributed to the research of scientists around the world.

Breakthroughs have been made on all solar fronts. But nearly every hard-won answer has revealed new puzzles: The ceaseless dance between plasma and magnetic fields makes it maddeningly difficult to tease apart cause and effect. Each major level of solar phenomena is influenced by the others, each has a direct effect on Earth, and each is still not completely understood. The momentum toward solving what solar physicists think of as the “big questions” isn’t likely to slow, given our ever greater need to predict space weather. And because, as astronomer John Harvey of the National Solar Observatory puts it: “The sun is the only astronomical object that critically matters to humankind.”

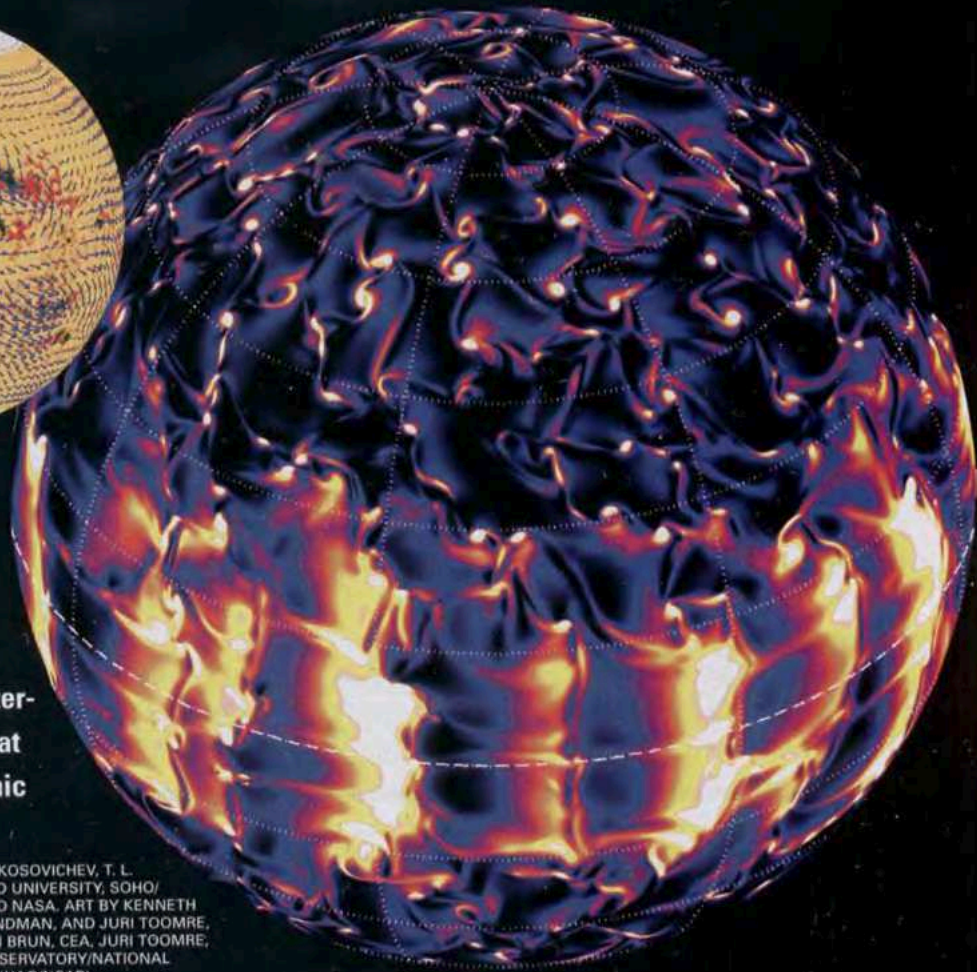




thousands of miles deep in the convection zone reveal shifting “jet streams” of plasma (above). Computer modeling (right) maps this internal weather—big fronts at the equator, small cyclonic storms at high latitudes.

CLOCKWISE FROM BOTTOM LEFT: A. G. KOSOVICHEV, T. L. DUVALL, JR., P. H. SCHERRER, STANFORD UNIVERSITY, SOHO/MICHELSON DOPPLER IMAGER, ESA AND NASA. ART BY KENNETH EDWARD, DEBORAH HABER, BRADLEY HINDMAN, AND JURİ TOOMRE, JILA/UNIVERSITY OF COLORADO, ALLAN BRUN, CEA, JURİ TOOMRE, AND MARK MIESCH, HIGH ALTITUDE OBSERVATORY/NATIONAL CENTER FOR ATMOSPHERIC RESEARCH (HAQ/NCAR)

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## of looking beneath the surface of a star.”

—John Leibacher, Global Oscillation Network Group

Among the big questions (in no particular order) are:

*What interior mechanisms produce the sun's mighty magnetic dynamo?*

The magnetic field drives virtually everything on the sun. Our star has an overall main magnetic field, with opposite north and south magnetic poles like the Earth's. Geophysicists believe that the Earth's field is formed by the dynamo-like motion of molten iron in the outer part of our planet's ultrahot core. Similarly, the sun's overarching field seems to be produced by internal motion of plasma.

Until recently, however, it was impossible to see anything beneath the blazing photosphere. Then in the early 1980s scientists developed a technique called helioseismology—a sort of ultrasound scan of the solar innards that

allows researchers to analyze the propagation of sound waves through the sun using the techniques geologists use to understand the interior structure of the Earth.

“Nobody dreamed 30 years ago that there would be the possibility of looking beneath the surface of a star,” says John Leibacher, program director for the Global Oscillation Network Group (GONG), a worldwide array of automated observation stations funded by the National Science Foundation and positioned about 60 degrees apart around the Earth to view the sun 24 hours a day.

The idea of analyzing sound waves originated in the 1960s, when a Caltech physicist named Robert Leighton used Doppler imaging techniques to show that the solar surface throbbed with rhythmic oscillations like the skin of a drum, with a frequency of about one beat every five



minutes. Solar astronomers later found more and different waves that resonate throughout the sun, and in the 1990s began to apply the science of acoustics to data from GONG and from space-based instruments like SOHO. As a result, “we’re seeing structures inside the sun that nobody expected,” says solar physicist Craig DeForest of Boulder’s Southwest Research Institute (SwRI).

Perhaps the biggest surprise is how the innermost layers revolve—especially when compared with the sun’s peculiar outer rotation. It takes roughly 26 days for the visible photosphere and the convection zone just below it to make a complete revolution at the equator, at about 4,400 mph, but about 36 days near the poles at a sluggish 545 mph.

Many scientists had long suspected that the inner layers of the sun—the core and the vast radiation zone—were spinning faster than the

upper layers. That turned out to be partly right. The inner layers are rotating as if they were a solid body, at one revolution per 27 days—slower than the upper layers at the equator but faster than at the polar regions. That means that the radiation zone and convection zone are spinning at very different rates as they slide past one another. Many experts now think this “shear” area, known as the tachocline, forms the dynamo that generates the sun’s main magnetic field.

“We hope that we’re not being too optimistic,” says Jack B. Zirker, former director of the National Solar Observatory, “but we now have a fair idea of how and where the dynamo comes about.”

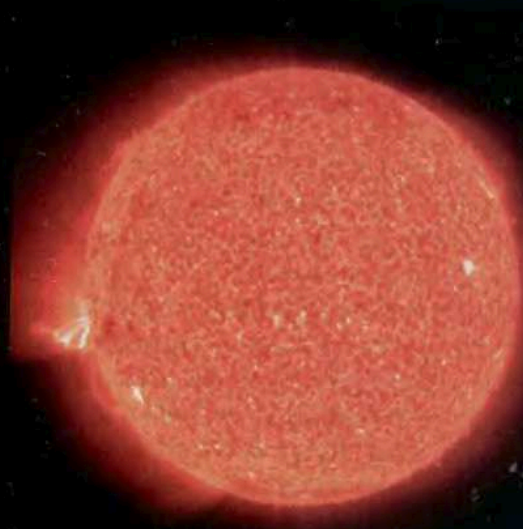
The internal shearing motion stretches and twists the north-south magnetic field lines, wrapping them around the sun. Doing so adds energy to them, just as stretching a rubber band stores energy in it. Sometimes this action creates

## Sunspots From Min to Max

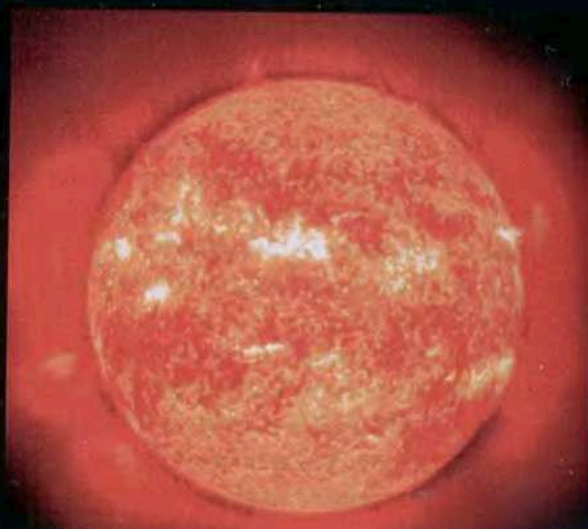
**THE HOLY GRAIL** for solar scientists is to understand the sunspot cycle. Sunspot activity goes from minimum to maximum and back over a period of 11 years on average, though it ranges from 8 to 15 years. During this time, the sun’s main magnetic field is reversing itself. The north pole becomes the south pole, then flips back during the next cycle. Sunspots form when monstrous bundles of magnetic field lines break the sun’s surface and mark where the magnetic field is strongest. Computer models of the field’s reversal (right, bottom) help researchers as they ponder: Why does the timing of the reversal vary? And why do some cycles produce many sunspots and others very few (graph)?

SOHO/EIT, ESA AND NASA (BELOW); GRAPH DATA FROM NASA; MAGNETIC FIELD MODEL BY MAUSUMI DIKPATI, HAO/NCAR

► View movie at [nationalgeographic.com/magazine/0407](http://nationalgeographic.com/magazine/0407)



**A** Solar minimum March 1996



**B** Solar maximum March 2000



powerful ropes of field lines that are buoyant enough to rise. They poke out into the photosphere as loops, prominences, and those enigmatic signposts of solar activity—sunspots.

*Why do sunspots fluctuate in 11-year cycles, and what effect does this have on terrestrial climate?*

When these titanic bundles of magnetic field lines bulge up and protrude, hernia-like, through the photosphere, they can range in diameter from 1,500 miles to several times the size of the Earth. Sunspots are visible because the bundled field lines impede the flow of convection. The center of the spot, the umbra, appears dark because it's a thousand or more degrees cooler than the surrounding 10,000°F photosphere.

Reliable references to sunspots date from first-century B.C. China, and they were seen by telescope in the early 17th century, but no one made a systematic count until a German astronomer, Samuel Heinrich Schwabe, began a tally in 1826. By 1843 he was confident enough to report that their number goes from minimum to maximum and back to minimum in about a decade's time.

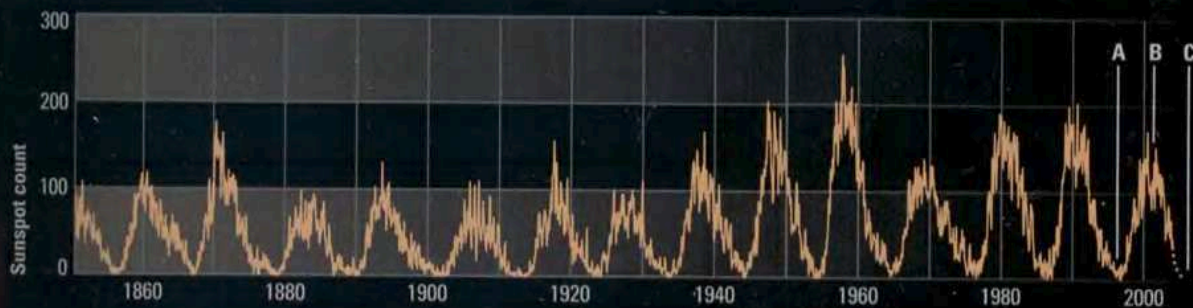
By 1915 American astronomer George Ellery Hale and colleagues at California's Mount Wilson Observatory had shown that the spots usually appear in pairs, aligned roughly parallel to the sun's equator, and that each half of a pair has the opposite magnetic polarity. Further, they determined that all spot pairs in the sun's northern hemisphere have the same orientation

and that all the spot pairs in the southern hemisphere have the opposite orientation. Clearly, the arrangement of sunspots is directly influenced by the internal wrapping of the sun's main north-south magnetic field.

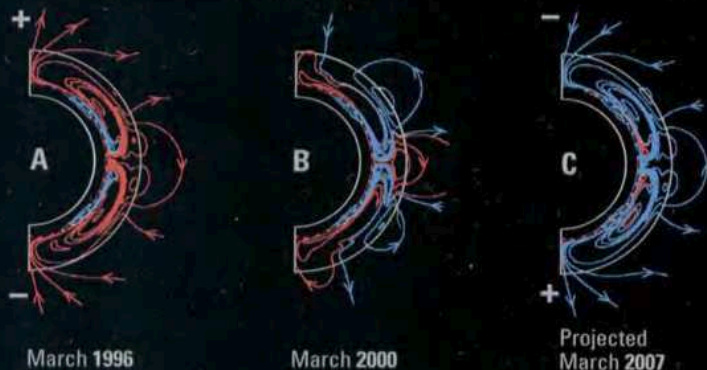
Every 11 years, on average, the sun reverses its overall magnetic polarity: Its north magnetic pole becomes a south pole, and vice versa. So a complete magnetic solar cycle—returning the sun to its initial orientation—actually lasts an average of 22 years. No one completely understands the entire process, just as no one understands why the Earth's field also reverses itself at seemingly random intervals, most recently about 780,000 years ago.

That's unfortunate, because there's evidence that sunspot cycles have direct consequences for human life. Witness the sobering case of the Maunder Minimum, the eerie stretch from 1645 to 1715 in which records show that practically no sunspots appeared on the solar face.

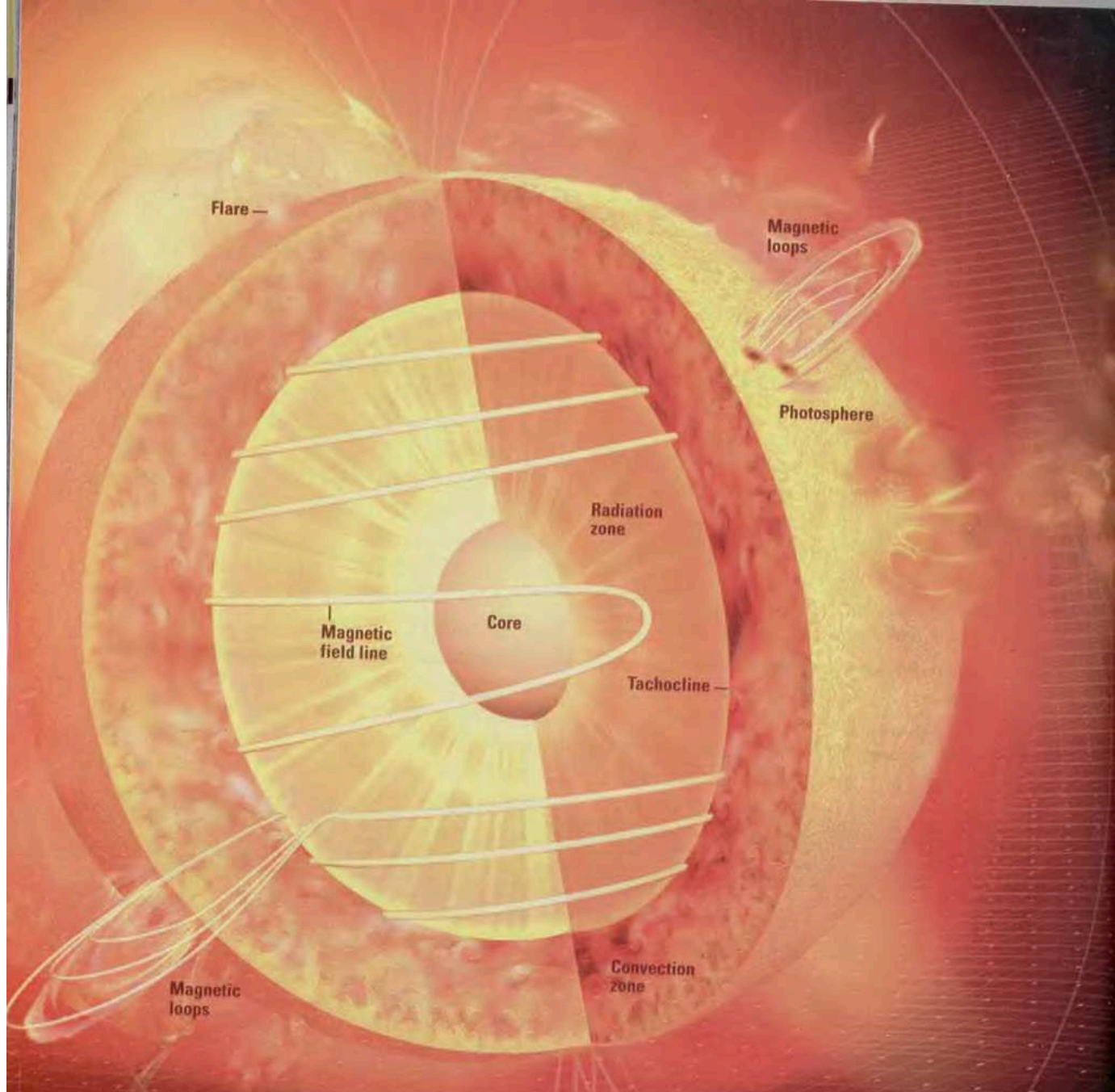
It was named after British astronomer E. Walter Maunder, who in the 1890s tried in vain to stir up interest in this aberration. In the 1970s American solar physicist Jack Eddy revisited Maunder's work, noting that the Minimum offered "a good test case for solar influence on climate." Eddy, like most solar scientists at the time, wasn't convinced that variations in sunspot numbers—the most visible indicator of solar activity—had any link to terrestrial climate. He examined data on the growth rings of trees from the 70-year-long minimum. *(Continued on page 28)*



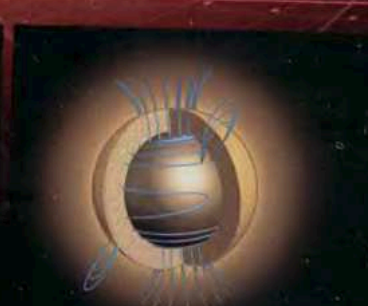
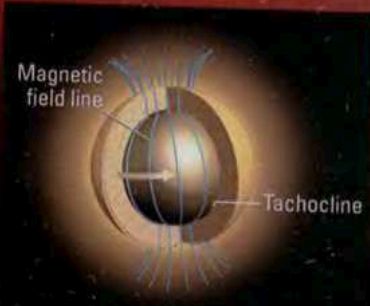
At solar minimum the magnetic field is strongest near the poles (A, red). Solar max (B) occurs as field strength concentrates near the equator, creating storms that can affect Earth. By the next minimum (C), a new polarity (blue) has been carried by plasma through the convection zone.







SIZES AND DISTANCES NOT TO SCALE.



### The Sun Revs Up

The cycle begins with magnetic field lines running from pole to pole—the field generated in the tachocline, where the radiation and convection

zones slide past each other. Since the sun's upper layers rotate (about 26 days) faster near the equator (about 36 days) than near the poles (about 36 days), the lines begin to stretch. As plasma churns and flows,

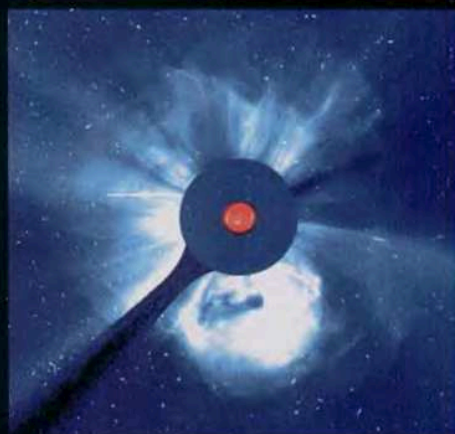
it further drags and distorts the lines, which energizes them. When field lines become twisted they gain buoyancy and rise, then break through the surface in a variety of breathtaking forms.



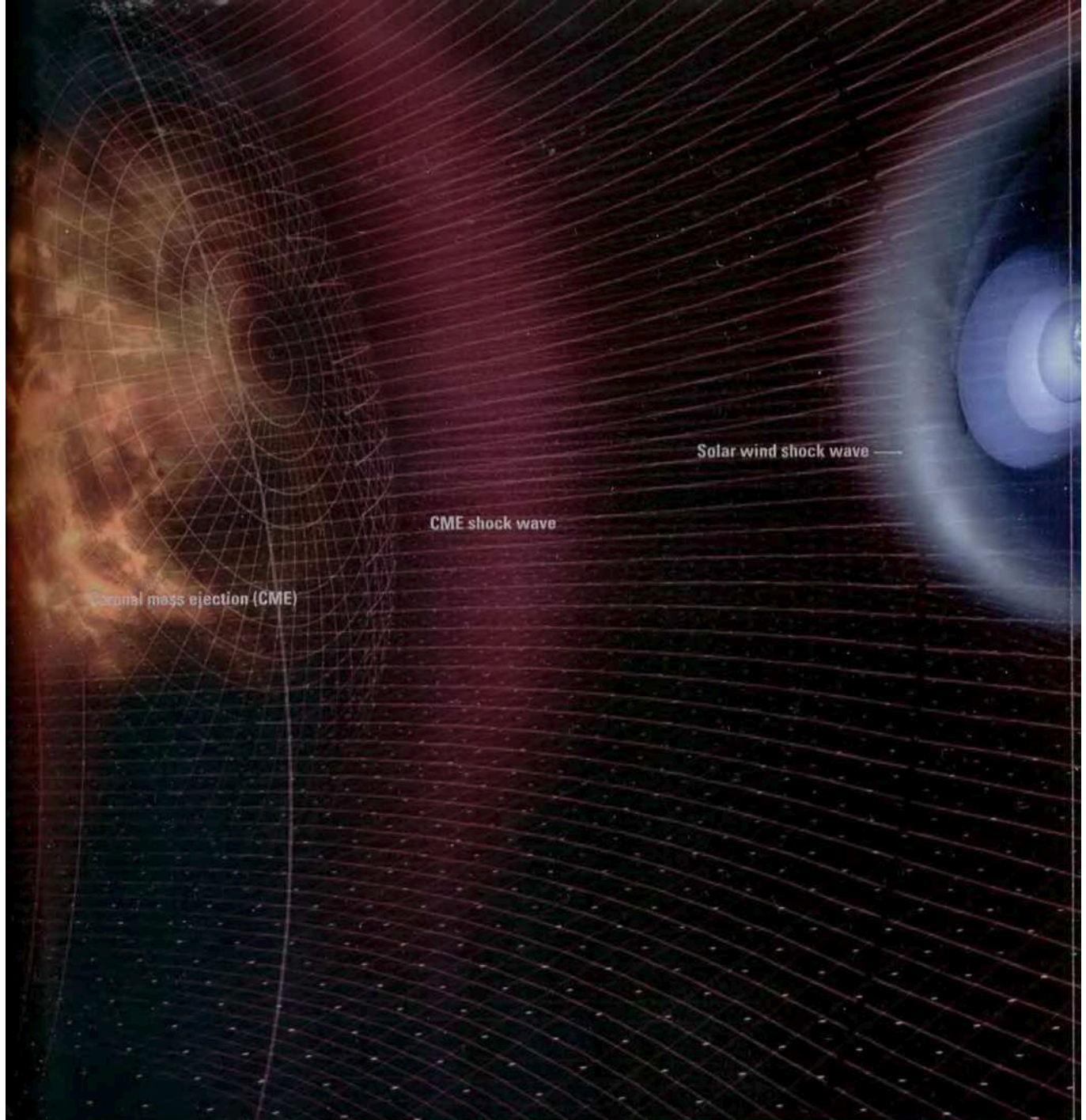
Earth in  
the line  
of fire

# Solar Storms

The height of the sunspot cycle—the solar max—is akin to hurricane season on Earth: Conditions are ripe for big blows. The sun's magnetic field is at its most tangled and turbulent. Energy builds in magnetic field lines and they snap, exploding as solar flares that hurl x-ray radiation at the speed of light. Similarly, but far more dramatically, a cloud of plasma—a coronal mass ejection, or CME (above)—surges into space with the energy of 200 billion Hiroshima bombs. Earth's magnetosphere, the shield created by our magnetic field, protects us from being physically harmed by these solar broadsides, but their effect on the technology we depend on can be dire. Flares can disrupt radio and GPS signals used in navigation. CMEs can disable satellites critical for communications, and the cosmic jolt of a CME can overload electrical grids, causing massive power blackouts. So the push is on to understand and predict these violent storms from the sun.



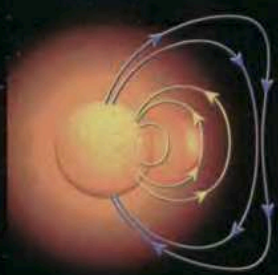




Coronal mass ejection (CME)

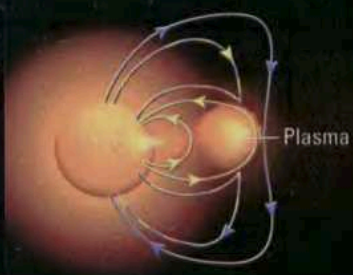
CME shock wave

Solar wind shock wave

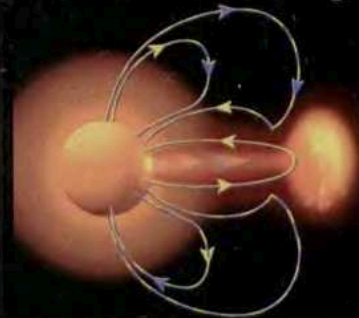


**A Storm Erupts**

What triggers a CME? Theory holds that coronal loops (blue and yellow) act like a net to restrain energized magnetic fields that are trying to rise,



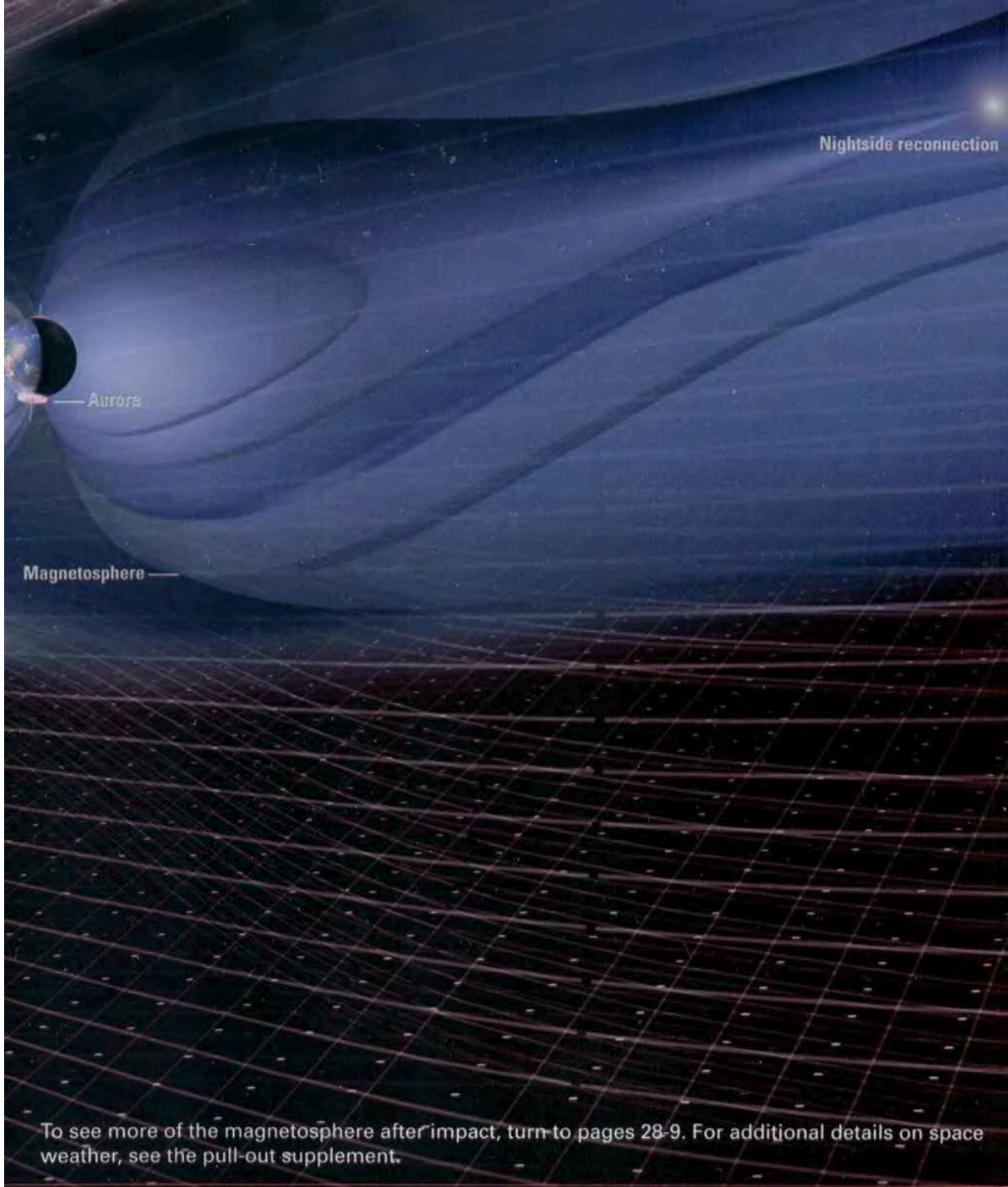
and pressure builds. Constantly in motion, loops can merge in a process called magnetic reconnection, which rips the net. A billion tons of plasma escapes at one to five million miles an hour,



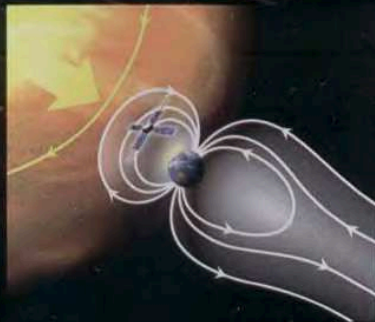
growing into a cloud tens of millions of miles wide. Barreling through the slower solar wind, a CME creates a shock wave that can boost its charged plasma and radiation to ultrahigh energies.

ART BY MOONRUNNER DESIGN, CONSULTANTS; SPIRO K. ANTIOCHOS, NAVAL RESEARCH LABORATORY (NRL); PÅL BREKKE, ESA; BERNHARD FLECK, ESA; PETER INTEGRATED SPACE WEATHER MODELING; STEELE HILL, SOHO/NASA; JAMES A. KLIMCHUK, NRL; GARETH R. LAWRENCE, ROYAL OBSERVATORY OF BELGIUM; JEFFREY



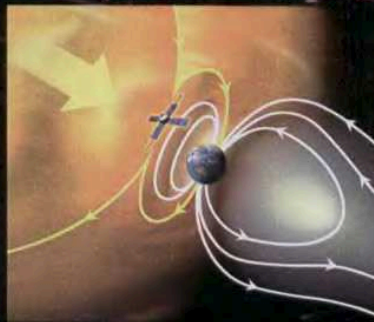


To see more of the magnetosphere after impact, turn to pages 28-9. For additional details on space weather, see the pull-out supplement.

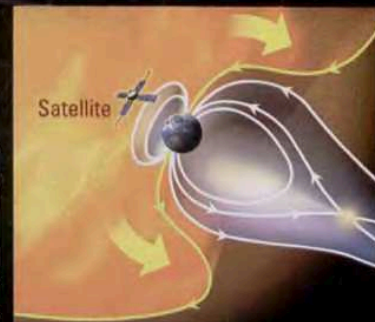


### Earth Takes a Hit

It takes one to three days for a CME to reach us. SOHO and other satellites detect its liftoff, but not until about an hour before impact can we measure



how bad it will be. In the worst case (above), a CME carries a southward magnetic orientation, the opposite of Earth's. Such a CME not only compresses our protective magnetosphere (exposing satellites



to particles), it also links to our dayside magnetic field and peels back field lines. Then, at the nightside tail, Earth's lines reconnect, driving trillions of watts of power into the upper atmosphere.



## Two of the strongest flares ever recorded flashed



10/28/03: Fast-forming sunspots loom—the bottom the largest in 13 years.



10/28: Fourth largest flare on record fires from bottom spot (enlarged below).



Twenty minutes later, CME is seen through SOHO's artificial-eclipse camera.

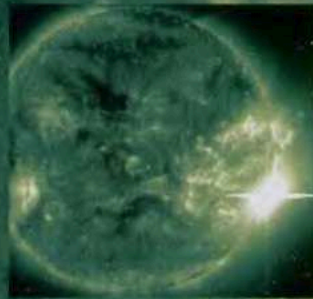
**A SPACE WEATHER ADVISORY** went out on October 21, 2003: "Intense active regions emerge on sun." In the next two weeks the sudden sunspot activity spawned more major flares and Earth-bound CMEs than had been seen all year. Airliners took more southerly routes, a small power blackout hit Sweden, and dozens of satellites suffered problems. The biggest Earth-directed salvo came on the 28th: a flare nearing the top of the record charts, followed by a CME moving five times faster than normal. But the CME, with a northward magnetic field, proved relatively minor. Then, just as the sunspots were rotating away from Earth, a parting shot: the largest flare ever recorded.



last fall during an astounding two-week tempest.



11/2: Nearly rotated away from Earth, the spots keep firing flares and CMEs.



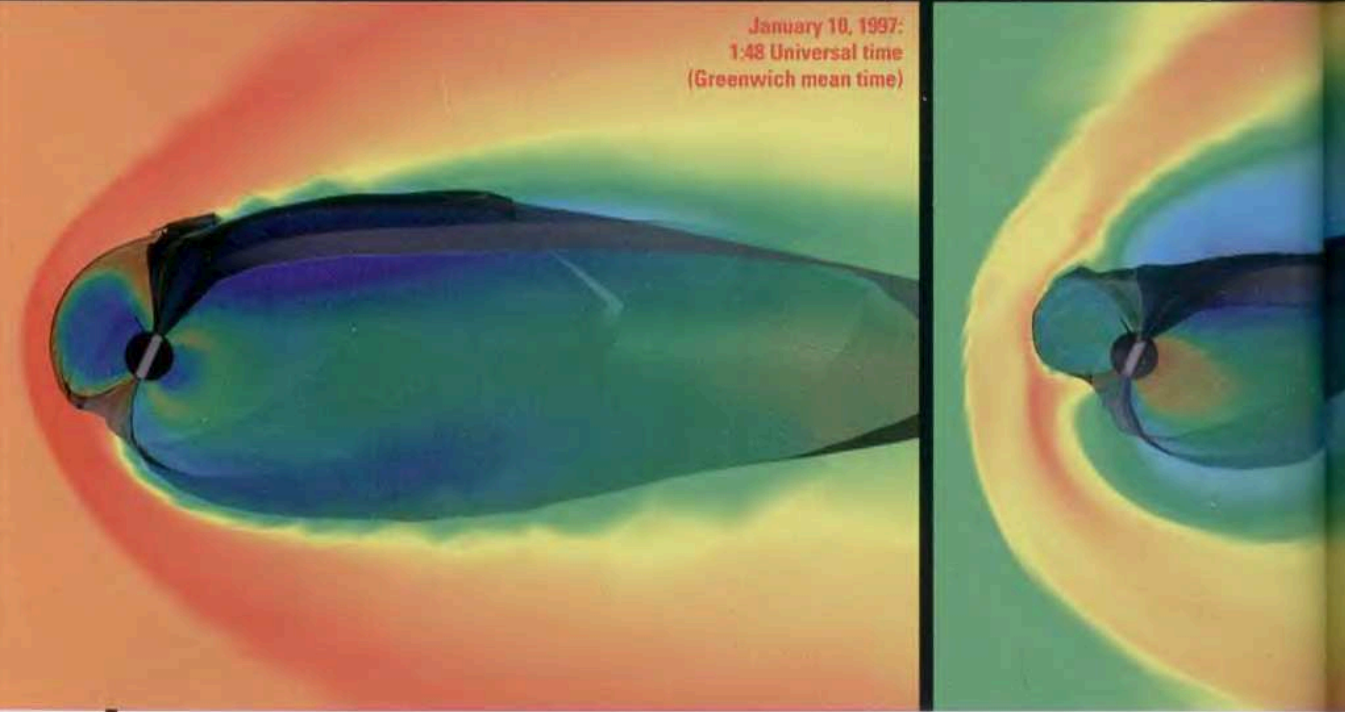
11/4: Most powerful flare on record blasts from same sunspot (enlarged below).



A fast-moving CME follows, but at an angle that only glances Earth.

Fortunately, it and the CME that followed only brushed our planet. Storms just after the solar max (the most recent ended in 2001) aren't uncommon. Still, the episode amazed scientists. Among the satellites hurt in the October outbursts was Mars Odyssey. The red-planet orbiter lost an instrument that, ironically, had just finished measuring the radiation levels that a crewed mission to Mars would face. As solar physicist Pål Brekke cautions, "If humans want to leave the magnetosphere, we've got to understand space weather."





January 10, 1997:  
1:48 Universal time  
(Greenwich mean time)

## Solar storms can overload power lines, causing

(Continued from page 21) They contained significantly more carbon 14 than trees before and after the period. That meant that higher amounts of cosmic radiation had been reaching Earth during that time. (A magnetically active sun reduces the cosmic radiation we receive.) So, Eddy concluded, there might be a connection after all.

Eddy's investigation also drew attention to another sunspot dearth from 1460 to 1550. Putting that episode next to the Maunder dates, scientists realized that these extended minimums coincided with the core of a famously frigid period in Europe and elsewhere known as the Little Ice Age (1400-1850), during which the Thames River in London and the Lagoon of Venice regularly froze.

It might seem as if fewer sunspots should mean a brighter sun. But the sun's luminosity is actually greater when there are more sunspots, because their magnetism creates extra-bright areas called faculae (page 16).

Sunspot activity has indeed been high over the past century as Earth's temperatures have climbed. But according to a recent NASA report, greater luminosity seems to account for only half of the global temperature increase before

1940, and less than that in later years as greenhouse gases have continued to rise. Swings in solar activity are only part of the puzzle.

Moreover, our knowledge of those swings is limited. Our best helioseismological studies and high-tech spacecraft observations only cover about 15 years. And as Joel B. Mozer, senior physicist at the Air Force Research Laboratory at Sacramento Peak, New Mexico, points out, "Since the beginning of the space age in the 1950s, we've had only four solar cycles. All our understanding is based on that. But there's plenty of evidence that these don't represent the extremes."

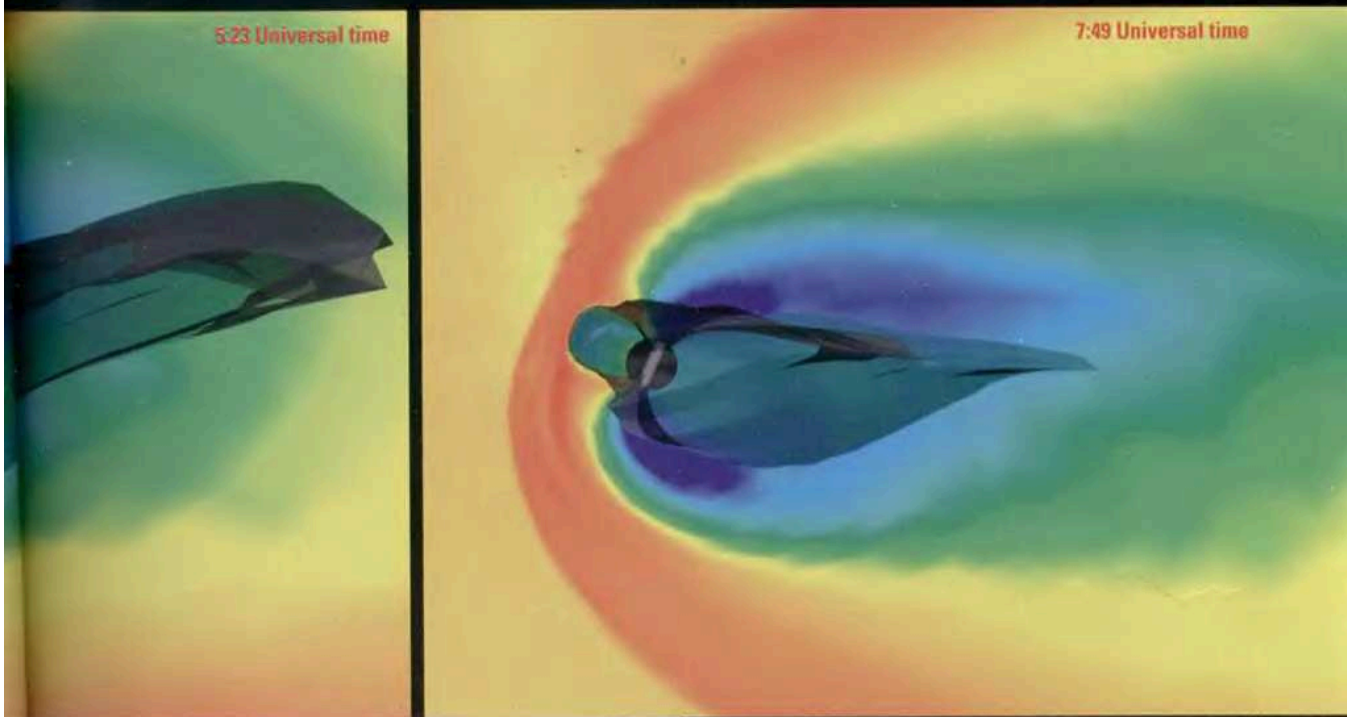
From computer simulations, scientists have a fair idea of how sunspots might arise and dissipate. But there are still too few highly detailed observations to compare with theory.

"The hope is that helioseismology will eventually give us better magnetic field observations at crucial depths," says Spiro Antiochos of the Naval Research Laboratory in Washington, D.C., who models the physics of solar outbursts. "Now we have to infer from the surface what's going on below. Even the simple question of the structure of the magnetic field under a sunspot—we just don't know."



5:23 Universal time

7:49 Universal time



## immassive blackouts.

*How is it possible that the corona—the ultra-rarefied halo of ions that extends millions of miles into the chill of space—is typically hundreds of times hotter than the solar surface?*

For the most awesome extremes of solar output, scientists look to the most inscrutable of the sun's features: the corona. Invisible except during a total eclipse, the corona and its lower altitude neighbor, the chromosphere—a 1,500-mile-thick band of plasma just above the visible photosphere—utterly defy the common-sense assumption that things ought to be cooler if they're farther from the surface of the sun.

The chromosphere is only one-millionth as dense as the photosphere. The corona is one-hundredth as dense as that. And yet, between the photosphere and the corona, "the proportional contrast in temperatures is about the same as if you were standing with your feet in liquid helium and your head encased in a blast furnace," says SwRI physicist Craig DeForest. The photosphere is about 5700°C, the chromosphere averages 10,000°C, and temperatures in the corona regularly top two million.

Where is that stupendous heat coming from? The leading suspect is a process called magnetic

**BEFORE THE STORM**, Earth's magnetosphere tapers in the solar wind (left). Colors show plasma density (red, highest; purple, lowest). **A CME's punch (center) deforms the shield and widens it over the Poles. Charged particles already in the magnetosphere dive in (above), creating awesome auroras.**

MICHAEL WILTBERGER AND CHARLES C. GOODRICH (ALL)

► View movie at [nationalgeographic.com/magazine/0407](http://nationalgeographic.com/magazine/0407)

reconnection, a splicing of magnetic field lines that causes energy to be released.

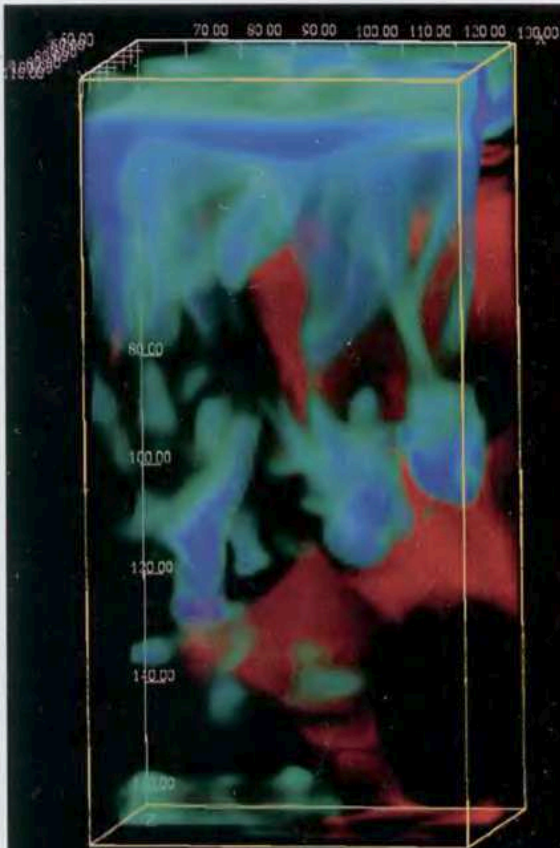
"A key SOHO discovery was that small-scale magnetic fields are constantly generated all over the sun just under the surface," says SOHO's U.S. project scientist Joseph Gurman of NASA's Goddard Space Flight Center. This "magnetic carpet" is made up of small loops arcing up from the photosphere. The bases of the loops are pushed around by plasma. When two lines are shoved together, their stored electrical energy grows to unmanageable levels. The lines break and reconnect with each other to form a lower energy configuration. The excess energy—sometimes billions of kilowatt-hours—is released in an instant.

"After decades of not being able to come up with enough energy for a coronal-heating model," says Gurman, "we now have a thousand times more energy than needed."







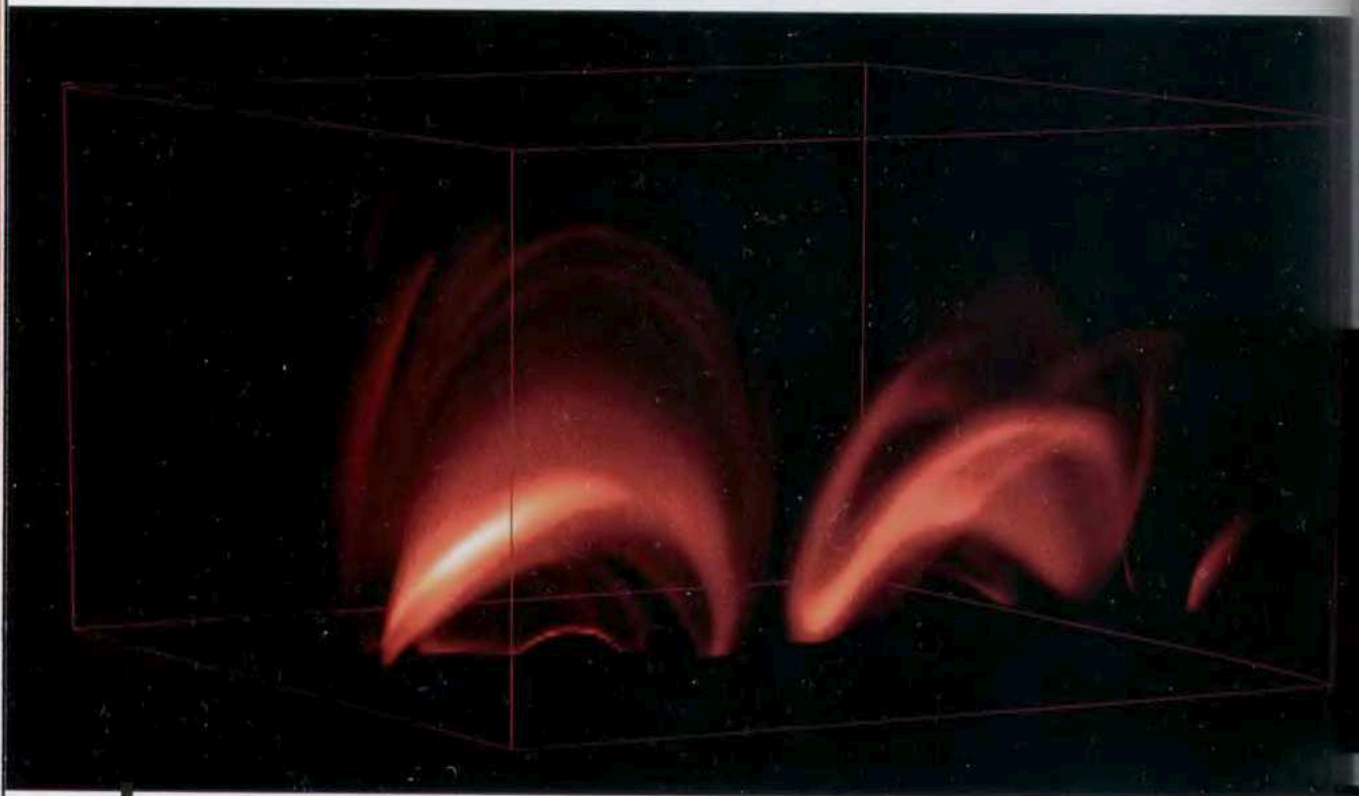


**MASTERWORKS** of computer simulation have played as much a role in fathoming solar behavior as advances in satellites and Earth-based telescopes. Direct images and data “tell us *what’s* there but not *why* it’s there,” explains astrophysicist Robert Stein. Discoveries made with theoretical modeling lead scientists to look for supporting physical evidence. Stein’s model of rising and falling convection currents (above; red is hottest plasma, blue coolest) simulates an area half the size of Earth. A thought experiment (left) by mathematician Fausto Cattaneo looks just below the sun’s surface. The colored filaments represent small-scale magnetic fields, which his model shows can be generated by plasma turbulence even where the sun seems quiet.

FAUSTO CATTANEO, UNIVERSITY OF CHICAGO (LEFT);  
ROBERT STEIN AND ÅKE NORDLUND

► View movie at [nationalgeographic.com/magazine/0407](http://nationalgeographic.com/magazine/0407)





"The sun is the only astronomical object



*What explains flares and the coronal mass ejections that are responsible for electrical tempests on Earth? How can these storms be predicted?*

The corona can produce what Robert Lin, professor of physics at the University of California at Berkeley, calls “the most powerful particle accelerators in the solar system—flares and CMEs. The biggest flares are equivalent to billions of megatons of TNT, all on a timescale of 10 to 1,000 seconds.”

Flares expel much of their energy as x-rays and are presumably generated when electrical currents are suddenly released as one or more magnetic field loops in the corona become strained to the breaking point and snap into a new shape. Traveling at the speed of light, the radiation reaches Earth in eight minutes and can disrupt radio communications and navigation systems. A small percentage of flares also hurl fast-moving high-energy protons that can cripple satellites.

But most of the four-alarm worry in the space weather community is devoted to CMEs and their particle barrage. Although CMEs often follow flares, these massive eruptions of plasma also frequently occur on their own. “CMEs fluctuate by many orders of magnitude,” says Joel Mozer, the Air Force Research Lab physicist, “and their flavor and character vary.”

They ordinarily take one to three days to reach Earth, where they smash into the planet’s magnetosphere, deforming it and—if circumstances are right—producing a multimillion-ampere ring current in the belts of charged

particles that continually circle the Earth. Even more threatening to communications satellites than flares, CMEs can also take out terrestrial power grids, leaving us in the dark.

It’s still not possible to predict when or if CMEs will erupt, because the trigger mechanism isn’t known. But with SOHO and other satellites now constantly monitoring solar activity, “we can see these storms leaving the sun in a way we never could before,” says Joseph Kunches, chief of space weather operations at the National Oceanic and Atmospheric Administration’s Space Environment Center in Boulder. “We can predict with 80 percent accuracy whether or not they will hit the Earth.”

Space meteorologists are also getting at least some warning on the velocity and magnetic orientation of the ejection. The magnetic polarity of a CME can change during its journey. If the polarity is the opposite of Earth’s, it does the most damage on impact because the collision of opposite-moving field lines produces enormous charges. Scientists get those readings only an hour or less before a CME strikes, when it passes a satellite called the Advanced Composition Explorer, or ACE. Like SOHO, ACE orbits around a fixed point in space a million miles from Earth, and is built to weather the storm.

The worst storms often come in the waning years after the solar maximum. The most recent solar max ended in 2001; November 2003 marked the strongest x-ray flare ever observed.

Scientists have been measuring flares for only a few decades, and CMEs weren’t even identified until the early 1970s. Have we really seen the outermost limits of what the sun can do? We can’t be sure. But by the time the next solar max rolls around—seven or so years from now—a new generation of solar observatories will be watching our stormy star, building on an era that for solar physicists has amounted to 20 years of good seeing. □

**THE FUTURE OF FORECASTING** space weather got brighter last year when astrophysicists Boris Gudiksen and Åke Nordlund achieved 3-D simulations (left) of coronal loops (top). A leap in understanding loops, their work also looks to the day when predictive models of solar activity can run as fast as the real thing.

TRACE, NASA (TOP); BORIS GUDIKSEN, ISP, AND ÅKE NORDLUND

► View movie at [nationalgeographic.com/magazine/0407](http://nationalgeographic.com/magazine/0407)

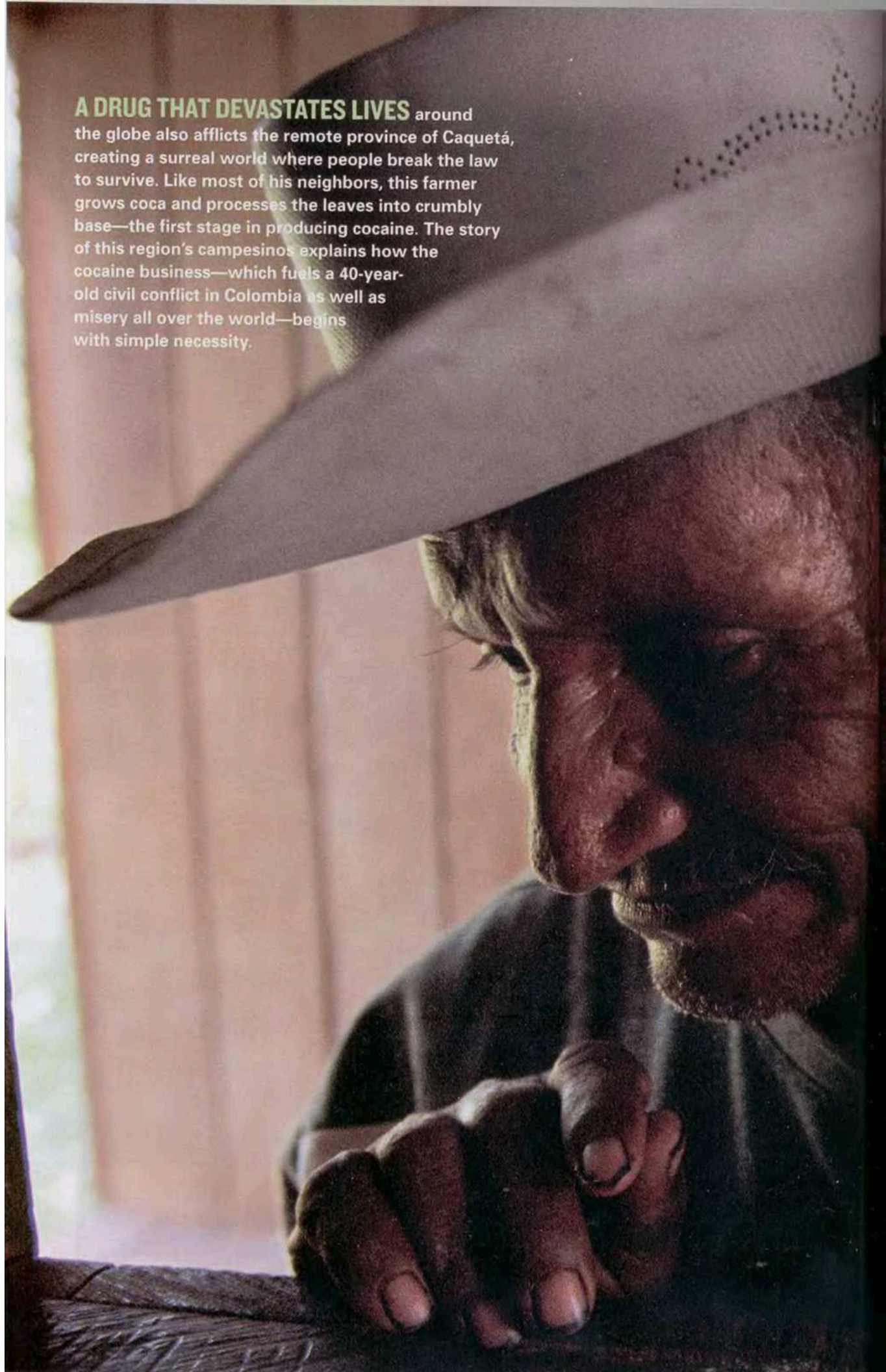
**HOW’S TODAY’S SPACE WEATHER?** Find out how to get the daily forecast online, and see more sun images—plus movies—at [nationalgeographic.com/magazine/0407](http://nationalgeographic.com/magazine/0407).

that **critically matters** to humankind.”

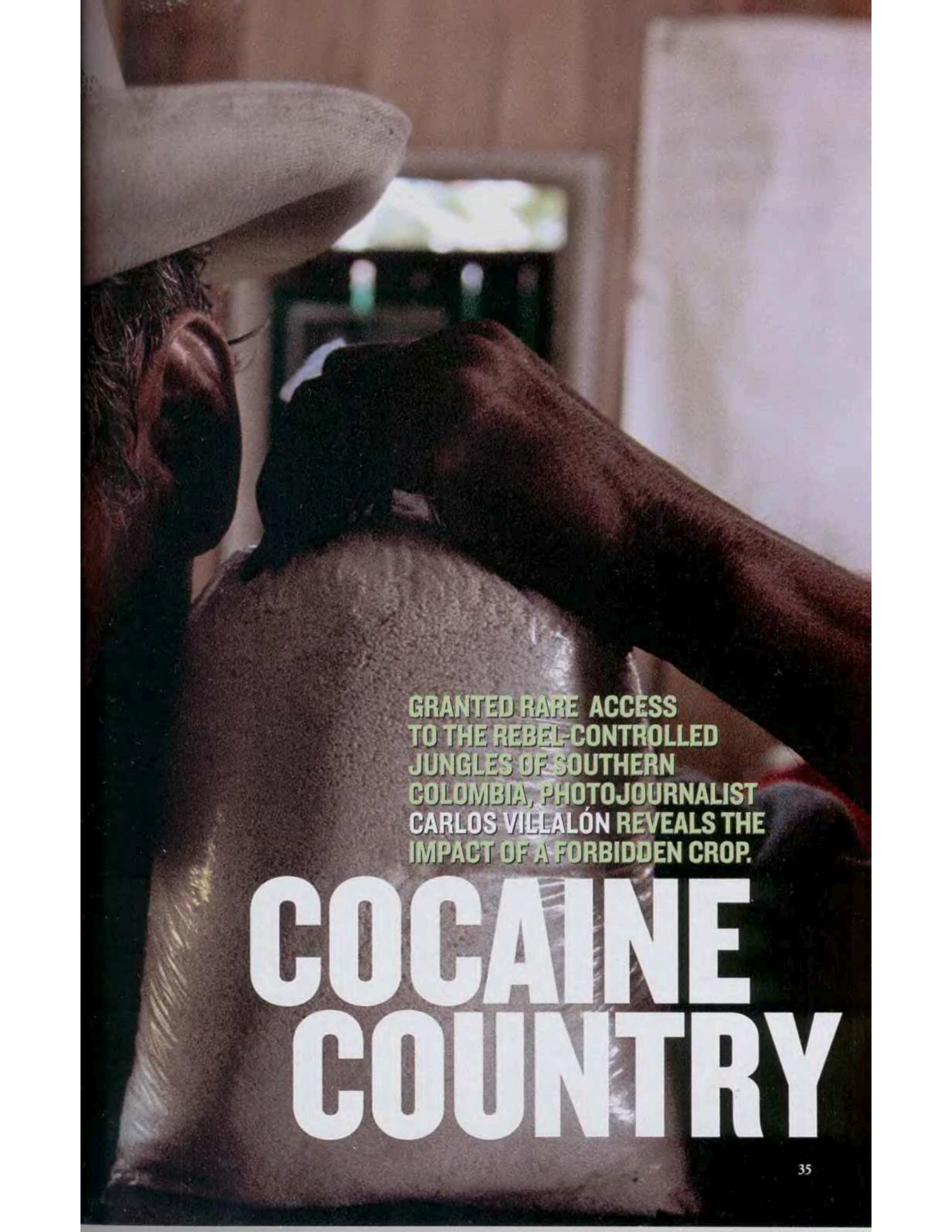
—John Harvey, National Solar Observatory



**A DRUG THAT DEVASTATES LIVES** around the globe also afflicts the remote province of Caquetá, creating a surreal world where people break the law to survive. Like most of his neighbors, this farmer grows coca and processes the leaves into crumbly base—the first stage in producing cocaine. The story of this region's campesinos explains how the cocaine business—which fuels a 40-year-old civil conflict in Colombia as well as misery all over the world—begins with simple necessity.








GRANTED RARE ACCESS  
TO THE REBEL-CONTROLLED  
JUNGLES OF SOUTHERN  
COLOMBIA, PHOTOJOURNALIST  
CARLOS VILLALÓN REVEALS THE  
IMPACT OF A FORBIDDEN CROP.

# COCAINE COUNTRY






Starting the production of base, workers in the village of La Playa shuffle water, cement, and lime into a morning's harvest to leach sap from the leaves. Further processing creates the easily transportable base, which is sent to hidden labs for refining. The world's biggest cocaine exporter, Colombia supplies most of what's sold in the U.S. and Europe.







A soldier in camouflage gear is kneeling in a forest, focused on packing or organizing equipment. He is surrounded by large trees and dense foliage. In the background, there are wooden structures and more equipment, suggesting a temporary camp. The lighting is natural, indicating it's daytime.

Early morning finds rebel soldiers packing up a camp shrouded by trees. Constantly on the move to avoid detection, these guerrillas are members of the Revolutionary Armed Forces of Colombia, or FARC, the largest insurgent group. The FARC earns hundreds of millions of dollars a year by taxing all cocaine transactions in its territory.







# CLEARLY I'D ENTERED A WORLD WHERE "BUSINESS AS USUAL" HAD ACQUIRED A TOTALLY NEW MEANING.

TEXT AND PHOTOGRAPHS BY CARLOS VILLALÓN

## The Right Connections

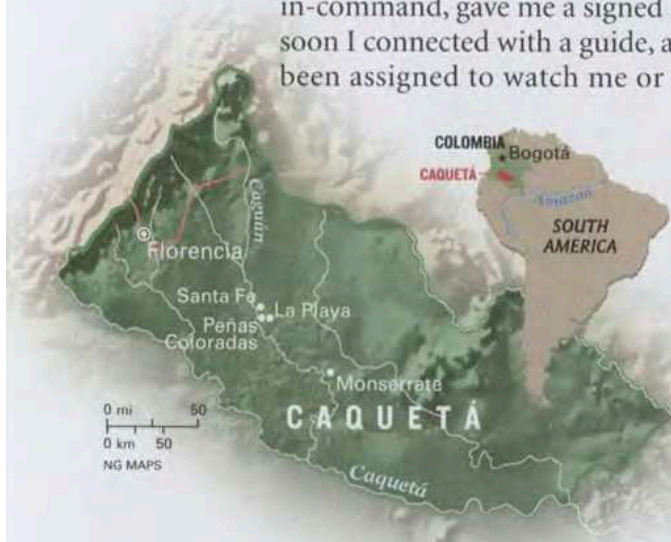
One afternoon, while crossing the soccer field in the village of Monserrate, I saw a man spreading white powder on three plastic tarps. What are you doing? I asked. "Drying cocaine base," he replied. "If it's wet, it'll be too heavy, and the dealer won't buy it." And no one minds? "Of course not," he said. "Everyone does it." Clearly I'd entered a world where "business as usual" had acquired a totally new meaning.

Fresh off the boat that brought me down the Caguán River, I was deep in the Amazon Basin of southern Colombia—territory held by the rebel army known as the FARC. Normally the FARC didn't allow journalists to travel here, and I'd been turned away before. But now I was accompanying a friend as she researched a book about life along the Equator. Apparently her plan seemed harmless enough, so the rebels waved us in. The locals were suspicious, though. Stone-faced and silent, they passed us on the street as if we were invisible—not a word, not even a nod. It was weird. But when we went into a store for sodas, we began to understand why strangers made them so uncomfortable. The customer ahead of us had put a bag of cocaine base (an early stage in cocaine processing) on the counter to pay his bill. I soon learned that merchants all over the region accepted base as payment for purchases, weighing out the right amount and handing back the remainder of the base in change. I'd been working in Colombia for a while and had photographed other rebel-held areas where coca was grown and processed, but I'd never seen anything like this. I knew I had to find out more about this incredible place—and for that I needed the right connections.

So I presented my case to one of the FARC's top commanders. Using a pseudonym, as all the rebels did, he called himself Fabián Ramírez. As I explained that I wanted to document the whole cocaine culture here, he listened thoughtfully—and then caught me by surprise. "That's a great idea," he said. "Do it." Sonia, his second-in-command, gave me a signed letter that would let me photograph anywhere, and soon I connected with a guide, a coca farmer named Rubén. I was never sure if he'd been assigned to watch me or was just being helpful, but without him I would

never have penetrated the surface of this place. On five trips over the next three years I explored a backwater economy supported by cocaine.

Agriculture took root in Caquetá in the 1960s as the government steered landless Colombians to what was then a sparsely populated region. Slashing and burning the rain forest to clear fields, neophyte farmers planted subsistence crops such as corn, rice, and yucca, but the land yielded limited rations. Market crops such as plantains and papayas failed because there were no roads to get

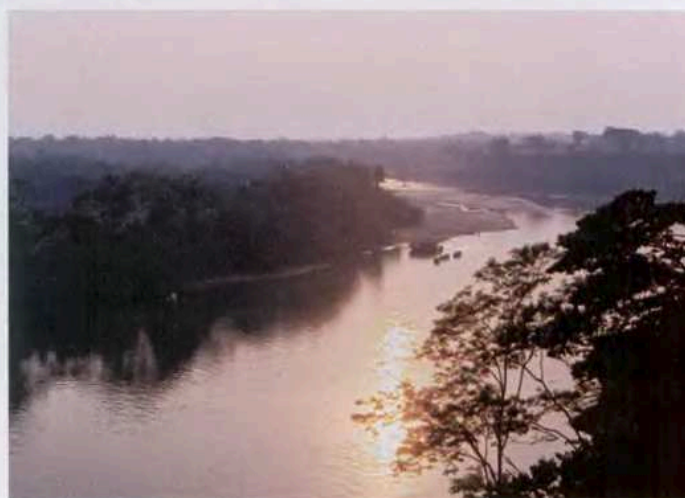






A market town springs to life on the weekend (above), when everyone from the nearby coca farms turns up in Peñas Coloradas to buy supplies, see friends, and hit the bars. The town has become a commercial center for the isolated settlements along a

90-mile stretch of the Caguán River (right and map, opposite). Surrounded by tropical forest, the river is the area's only highway. A fleet of boats—La Línea, or the Line—provides transport, but getting supplies into the region this way is expensive.



produce to customers quickly. Then, in the 1980s, the drug cartels based in distant Medellín and Cali enticed the region's farmers to grow coca. The cartels bought the farmers' semiprocessed output, refined it, and sold the end product, cocaine. Business boomed in the 1990s as international efforts shut down many coca plantations in Peru and Bolivia and farmers in Colombia filled the void. When the Colombian government finally crushed the cartels in 1995, the FARC saw an opportunity. It was already promoting leftist politics in Caquetá and taxing drug deals on the side. Now it could assess every farmer and newly independent trafficker in the region. But first it had to tame towns running amok after decades of official neglect.





## Law and Order

Before the FARC laid down the law, this region was like the Wild West, where going into town meant risking your life. Much of the trouble came from migrant workers who'd poured in to pick and process the coca harvest. Working long hours and making pretty good money, they roamed the streets at night and spent recklessly. Parties rocked bars, which today bear the names Saigón and Tronco Mocho, or Tree Stump. Alcohol flowed, gamblers crowded the cockfights, and customers kept the brothels busy around the clock. Saturdays were in a class by themselves: Full of beer and *aguardiente*, the local liquor, the men would pick a fight over anything—a woman, a wager, a perceived insult. With most of the population carrying a machete or a gun (customary gear in the countryside), several drunks and passersby would turn up dead on Sunday morning.

By the time I arrived for the first time in December 2000, the FARC had long since





Walking her beat in Santa Fe, a guerrilla called Mary shares a few words with a soccer player. To patrol the streets, regional FARC leader Fabián Ramírez has assigned a female commander to each town—because, he believes, women relate to the locals

much more warmly than men. Before I got the FARC's permission to work here, I photographed a man in a store where cocaine base is bartered for supplies during the slow dry season (below). My sudden appearance made him smile nervously.

## TWENTY YEARS AGO THIS REGION WAS TOTALLY CHAOTIC



taken control, and the crazy days were over. In fact, in all the weeks I spent here, I came across just one murder—a mysterious case of a cattle rancher shot dead from a passing boat, which stunned everyone. The FARC had produced a strictly enforced code of conduct: No drinking from Monday to Friday. No brawling. And, ironically, no drug use. These days, anyone caught breaking a rule is sentenced by the FARC to work on a development project in the trackless interior of the forest—building a bridge, for instance, or opening a road—things that a government would usually take care of. Drinking on a weekday or a first-time drug offense may get the culprit a couple of months. Murder brings a year-long penalty, at the very least. After investigating the infraction, the town's FARC commander sends word for the guilty party to show up at the FARC office with his bags packed and his affairs in order for the time he'll be away from home. Few dare to ignore the summons.





**"WE KNOW THIS DRUG**





Doing business bare-chested, a dealer weighs the bags of base that farmers have brought to Santa Fe to sell. Paying cash from the sack between his legs, he'll buy about 300 pounds today. At his side an assistant notes every purchase so the FARC can collect a 30 percent tax. Farmers are troubled by their role in the drug trade but say they have few alternatives.

**IS HARMFUL, BUT FOR US IT MEANS SURVIVAL."**



In cocaine country, goods and services can be purchased with either pesos or base. Flush with cash, a local offers a fisherman 10,000 pesos—about four dollars—for *bocachico*, the catch of the day (right). Waiting to see the doctor in Peñas Coloradas, two prostitutes (below) have

## CASH AND COKE CIRCULATE SIDE BY SIDE

brought a bag of base to settle their bill—the same currency they received from clients. If they pass their weekly, FARC-mandated medical exam, the doctor will give them a permit to work the next weekend. Later he'll sell the base to a dealer for hard cash.







## Business Cycles

During most of the year a dealer makes his rounds about once a week, usually borrowing a building on the outskirts of each town for a few hours on weekends. The word goes out, and farmers line up. An average month's harvesting gives a farmer about a kilogram of base, slightly more than two pounds. The dealer tests it by burning a small amount in a spoon: Base made properly simmers; the bad stuff pops and spits. For good quality, the dealer pays roughly a dollar a gram, or about a thousand dollars for a kilo bag. After a farmer buys supplies and pays his workers—the pickers and the men who produce his base—he may net as little as \$325.

The dry season, January and February, brings stingy harvests as the coca bushes falter and grow fewer leaves. Dealers only show up once in a while, cash gets tight, and everyone uses base like money. Most businesses weigh out grams to cover a bill, but the bordellos make it easy: One shot glass of base seals the deal.





**"THE GOVERNMENT**






Already skilled with machetes, the sons of my guide, Rubén, prepare cuttings to plant in a new coca field near La Playa. Growing one crop type and constantly applying pesticides and herbicides exhausts the soil. Every year coca farmers in Caquetá abandon as many as 30,000 unproductive acres and move onto virgin land, which they clear by burning down the forest.

**ISN'T HELPING US. WHAT ELSE CAN WE DO?"**





A farmer nicknamed Mazamorro, or Mushy, tends a batch of base drying under a heater as his wife brews coffee in the kitchen. Many people told me they wanted to quit growing coca; Mushy actually did. A year after I took this photo, I met him on the street in Peñas Coloradas. "I've completely changed my life," he said. "I'm raising chickens and vegetables to sell here in town."









## Guerrilla Tactics

To get to Fabián Ramírez's camp, I rode with him one night under the cover of the forest canopy as government helicopters circled overhead. With the car lights off, he navigated between trees and over simple planks spanning streams. Across a clearing a flash of friendly headlights helped him find his way. The danger was real. This past February the Colombian Army captured Sonia, the commander who had signed my permit to photograph. Authorities estimate that in the past decade she was responsible for allowing more than 600 tons of cocaine to reach the U.S. and Europe. Colombia is cracking down on cocaine production in FARC territory, though right-wing paramilitaries linked to the armed forces are profiting from the drug elsewhere.

**▶ BRAVE THE JUNGLE** Experience cocaine country with Carlos Villalón as he narrates *Sights & Sounds*, a multimedia presentation. Then join our forum on the cocaine trade at [nationalgeographic.com/magazine/0407](http://nationalgeographic.com/magazine/0407).





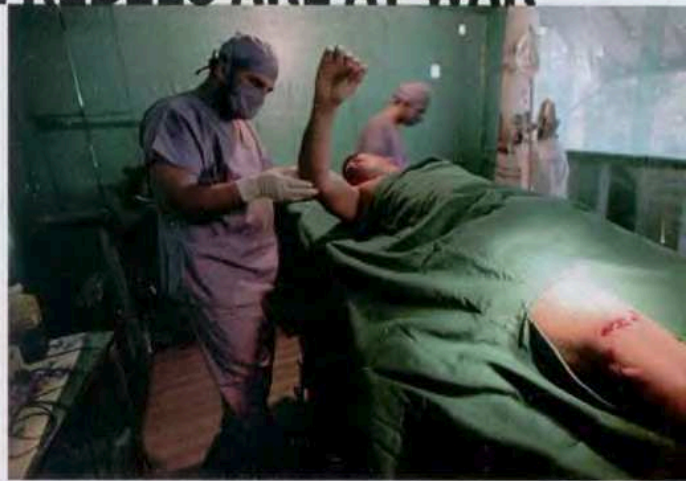
At a secret location deep in the forest, FARC special forces (left) guard the camp of commander Fabián Ramírez—a prime target for the Colombian Army as well as paramilitary forces.

Somewhere along the Caguán River, a tent houses an operating room where

a doctor (below) extracts bullets from a guerrilla shot by paramilitaries. “I can do everything but brain surgery here,” he said.

Serving time in the open, lawbreakers build a bridge (bottom) to connect Peñas Coloradas with a nearby village.

## MAKE NO MISTAKE— THE REBELS ARE AT WAR



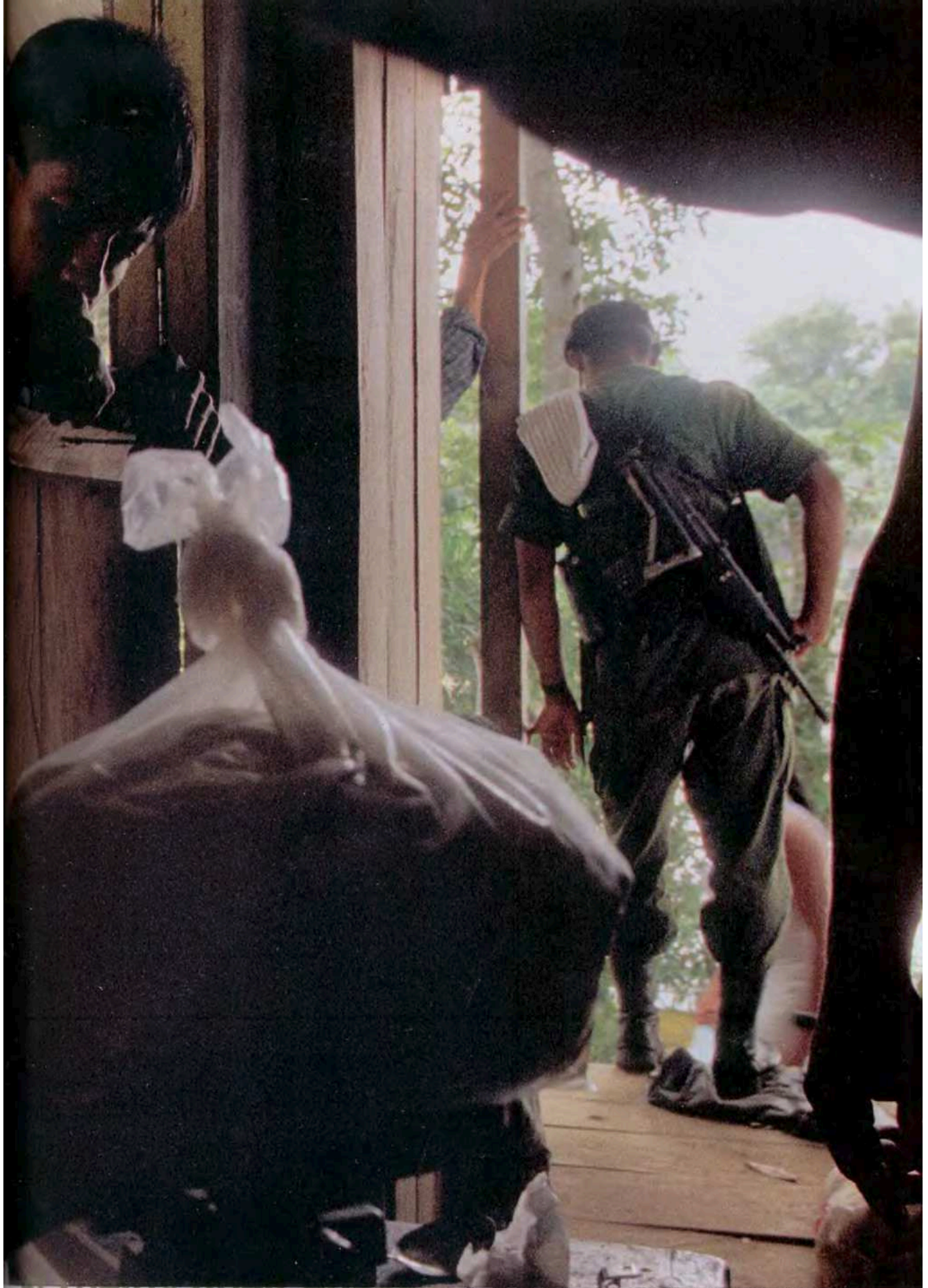


With a FARC guerrilla standing by for security, a dealer weighs about a kilo of base in a shack across the river from Peñas Coloradas. Depending on the market, the cocaine made from this base may sell for \$70,000 on the street—nearly 80 times what the farmer at the window gets. Barely able to meet his expenses, he'll have to gather yet another illicit harvest. □



"WE'LL HAVE TO KEEP

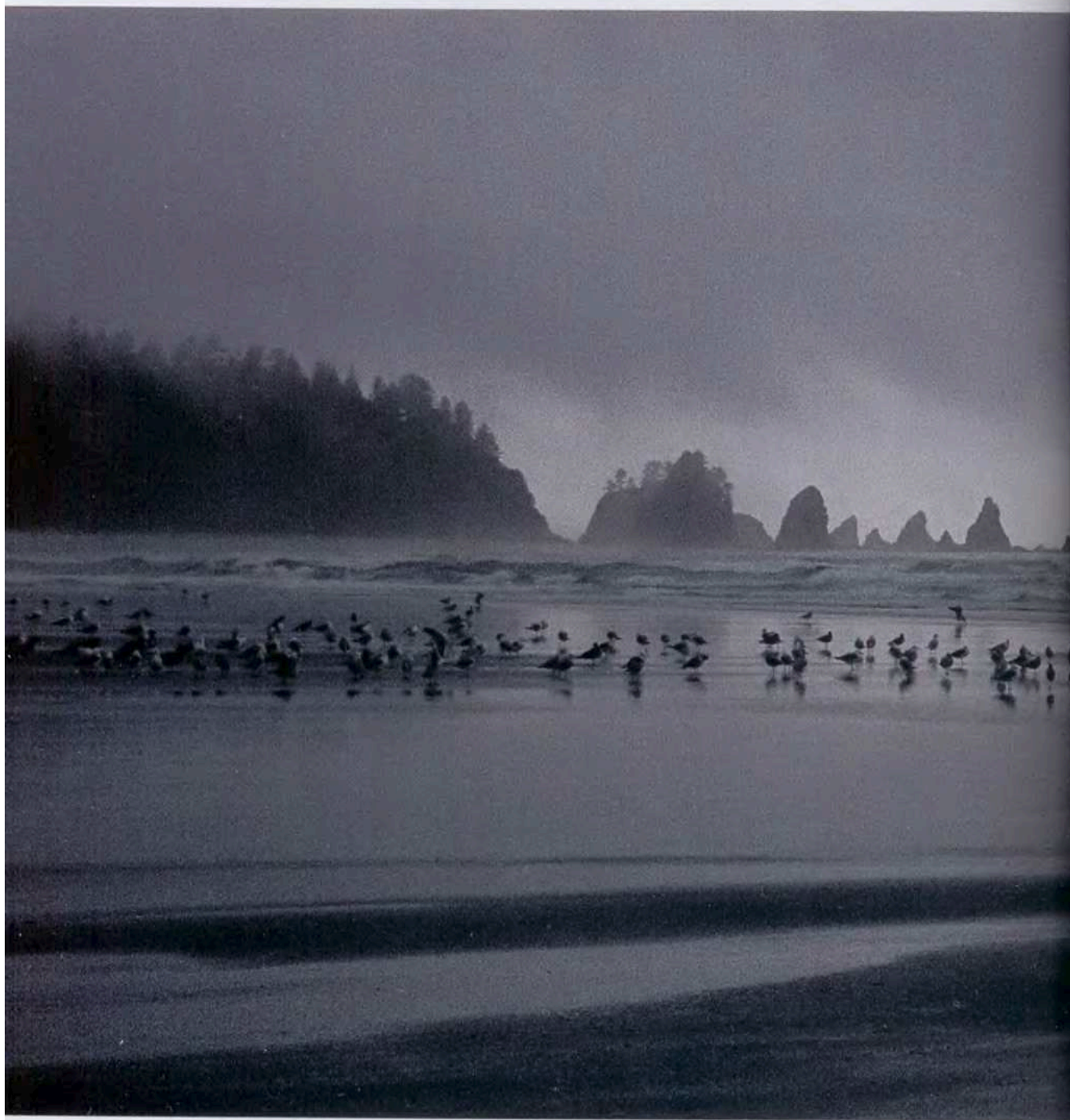




**PLANTING UNTIL THERE'S A REAL ALTERNATIVE."**



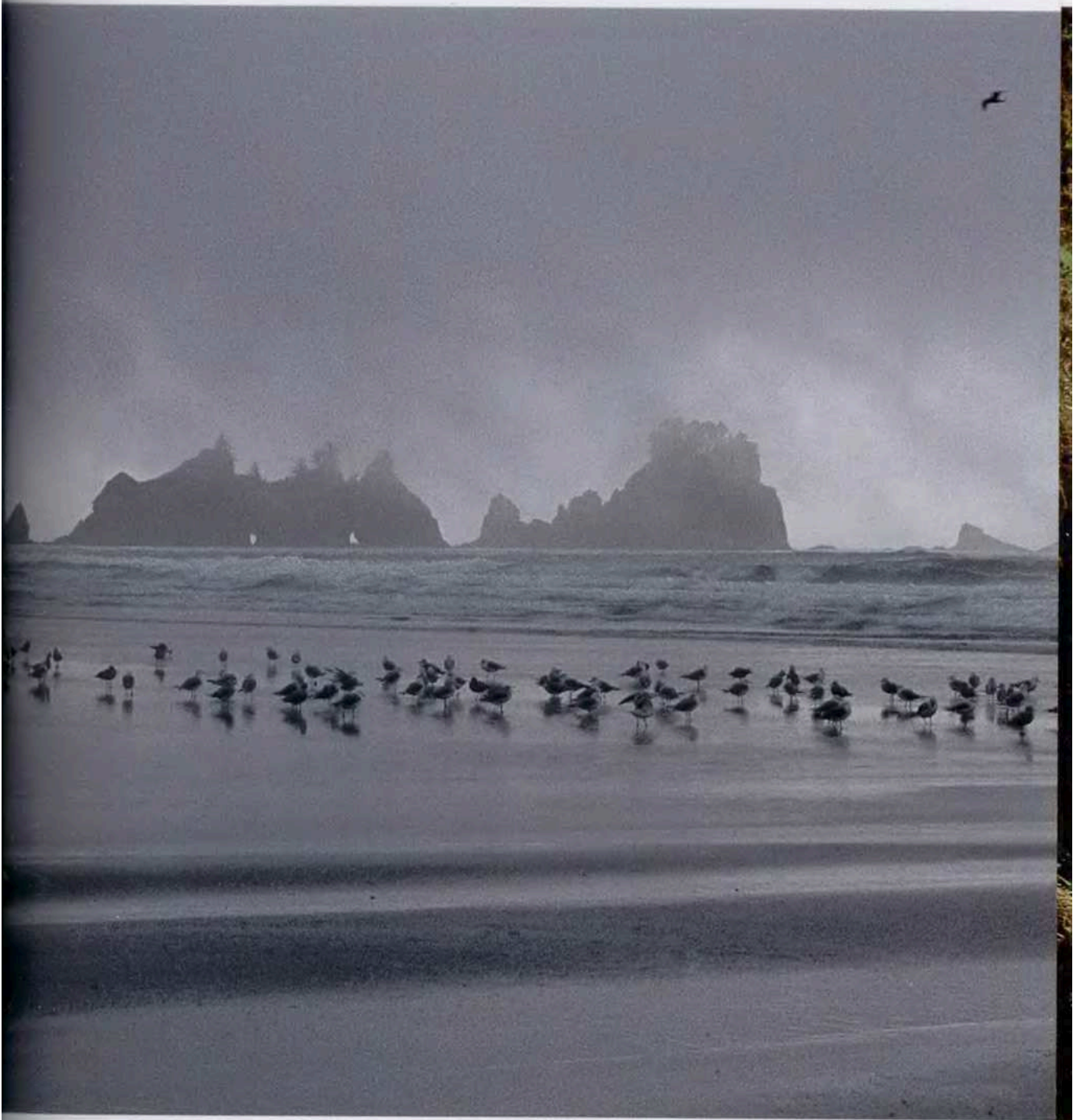
A M E R I C A N L A N D S C A P E S



# Nature's

O L Y M P I C





# Champion

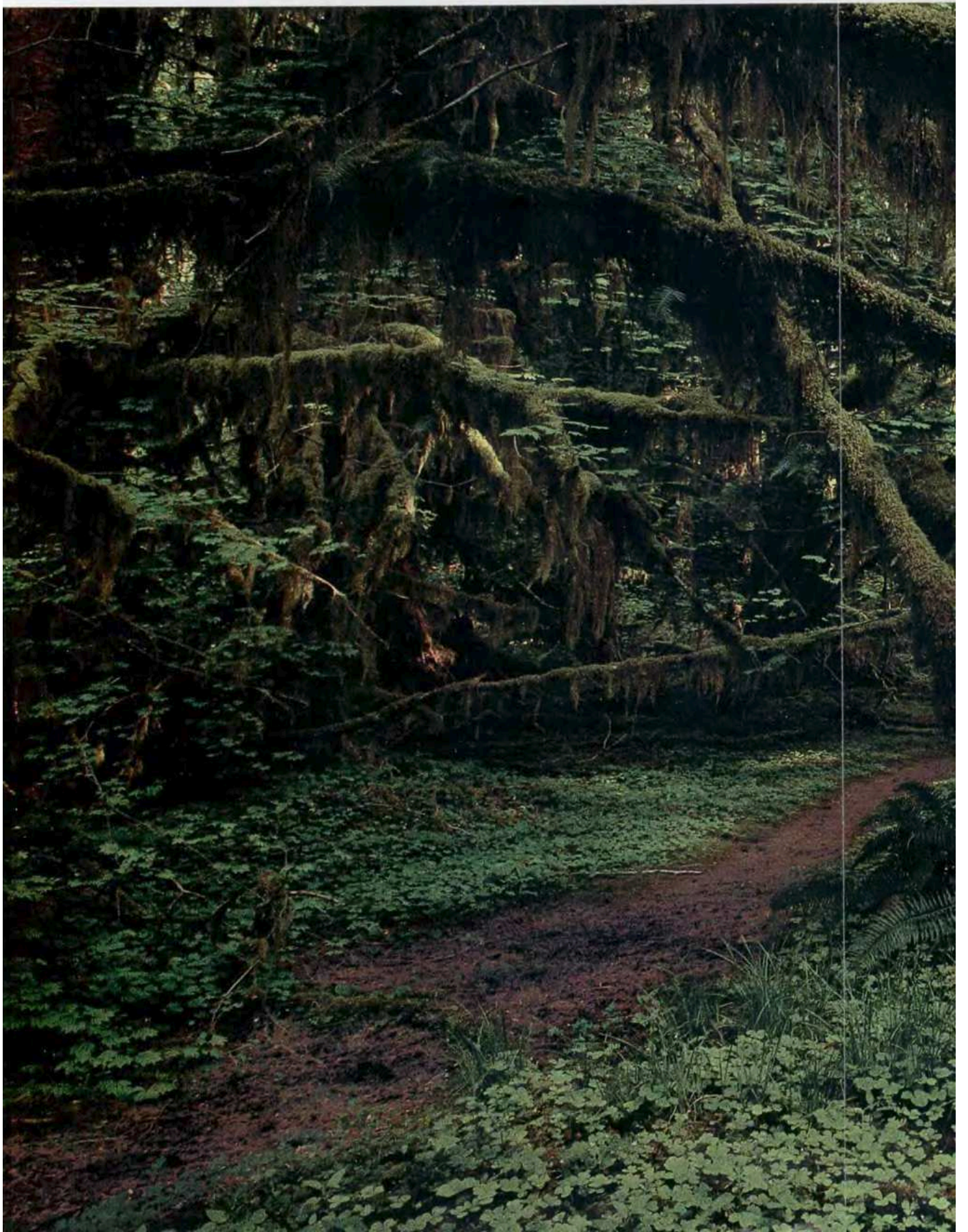
NATIONAL PARK



THE PATH LESS TAKEN

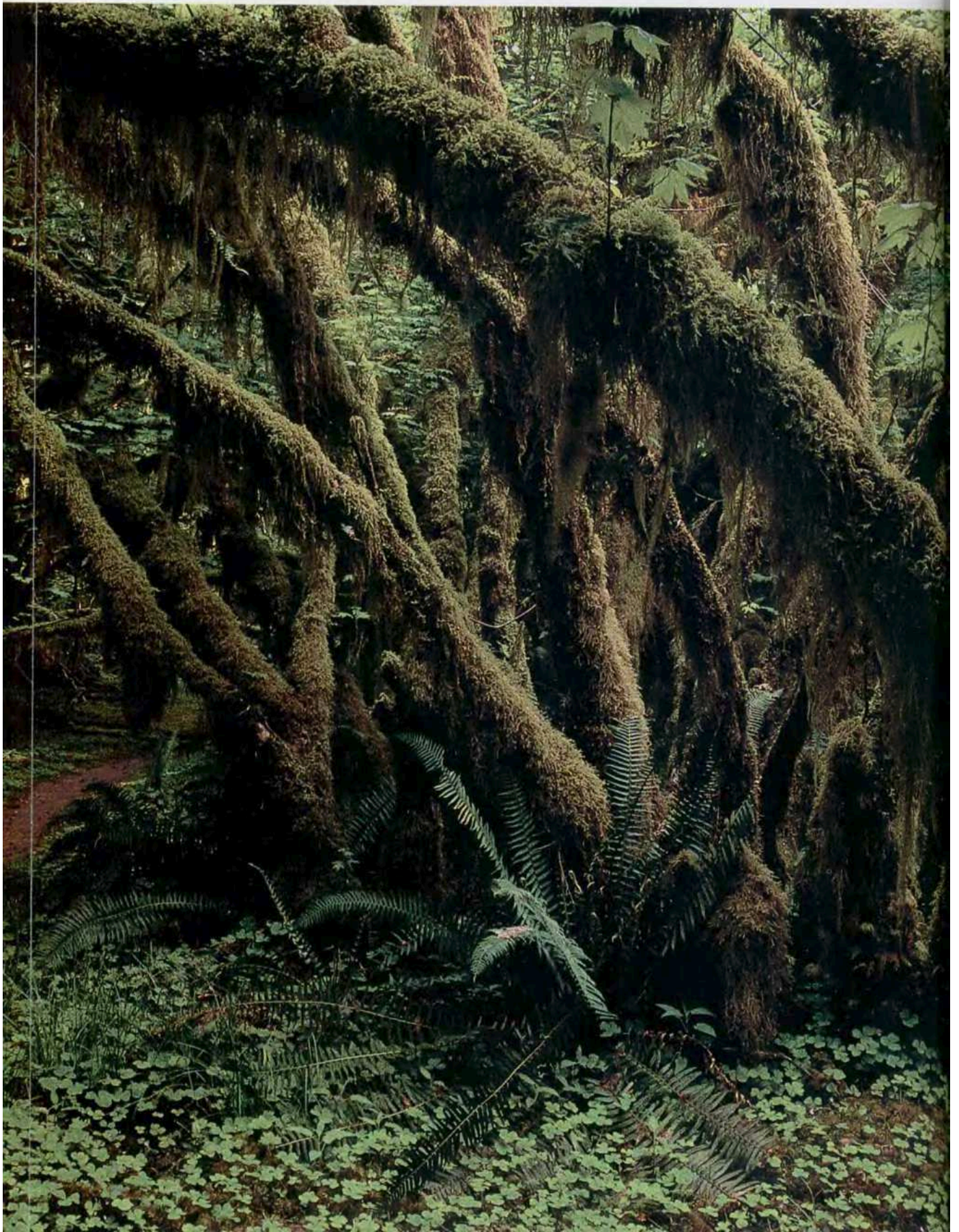
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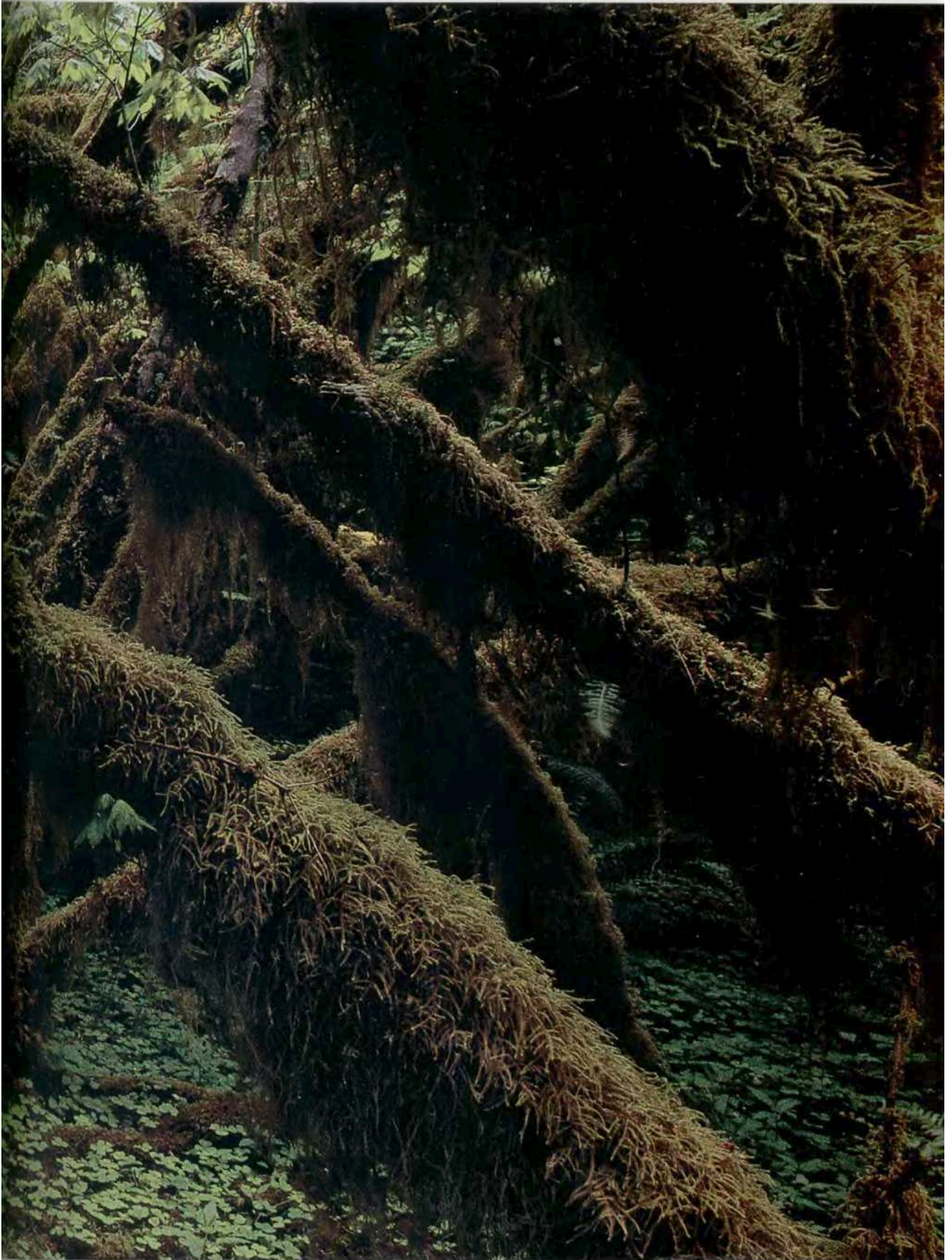




*As lush as any hobbit's realm, the forest engulfs Sams River Loop Trail, a route traveled more by elk than by humans. The path winds through a primeval world where lichens, mosses, and other epiphytes coat the branches of vine maples that arch over carpets of wood sorrel.*



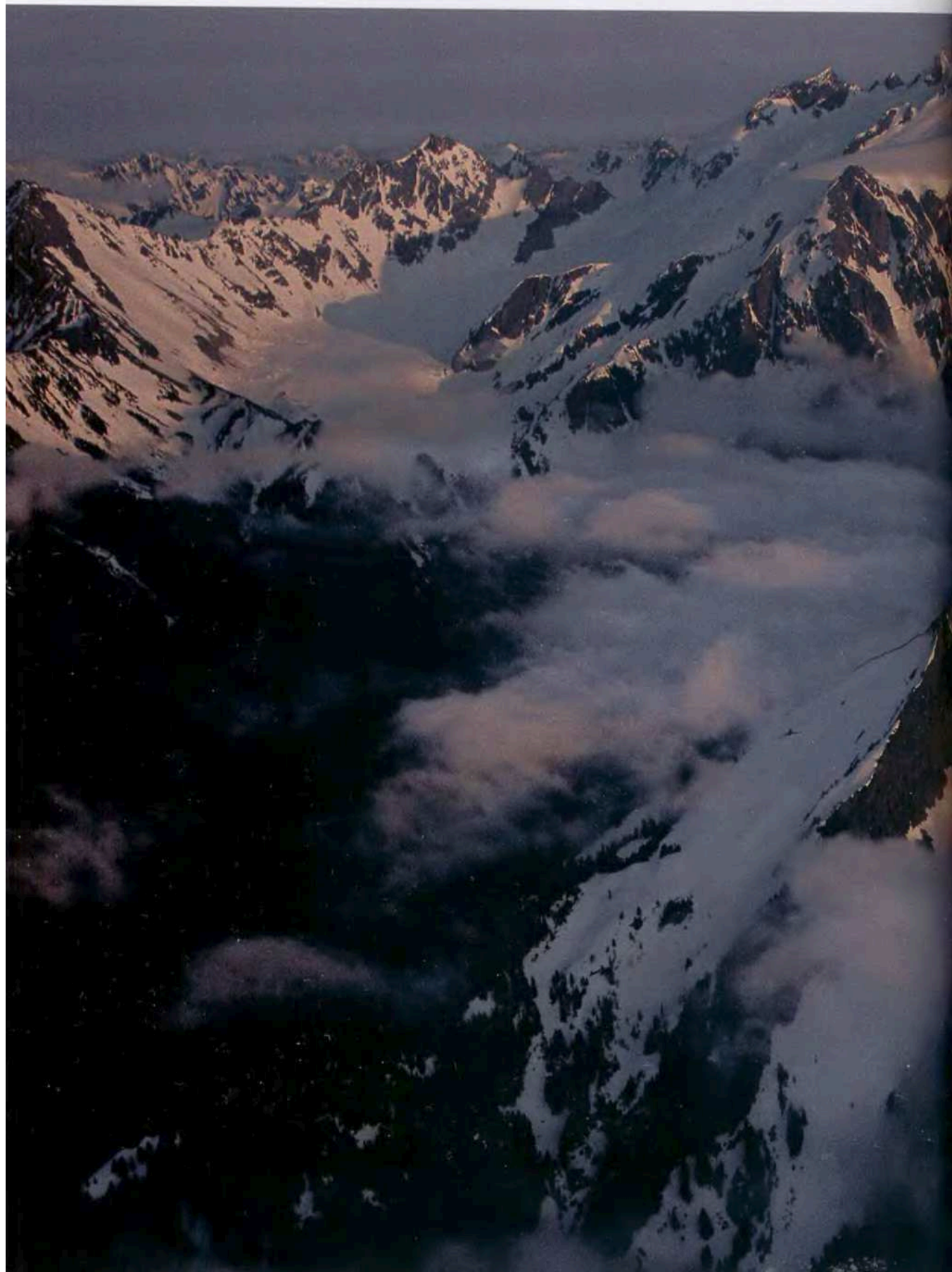






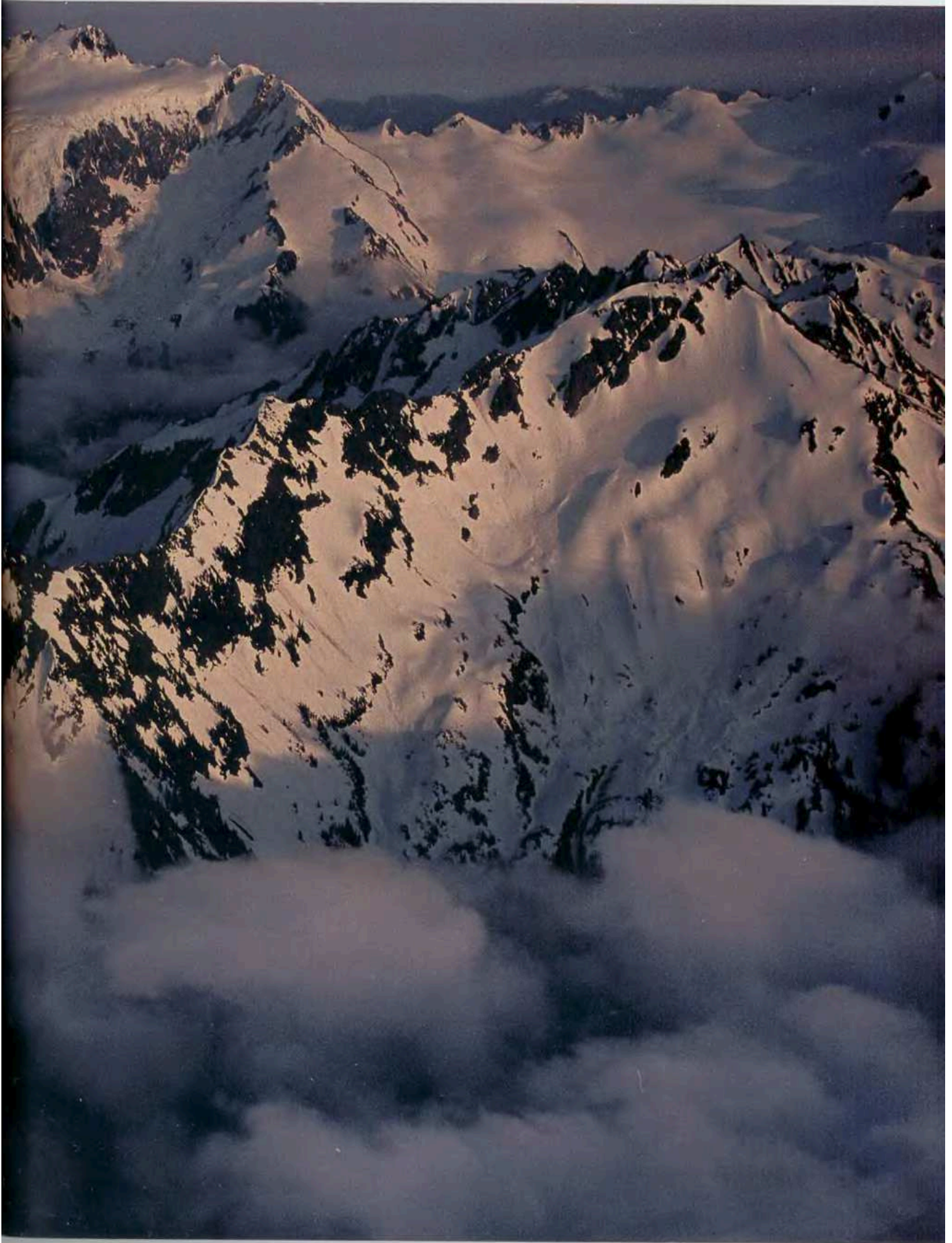
THE WEATHER MAKERS

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*Rising nearly 8,000 feet, Mount Olympus, at top center, and its sister peaks govern weather. When sodden ocean air blows in, the mountains force it to high elevations where it cools, releasing moisture: more than 200 inches of precipitation—mostly snow—a year.*





**A** NAME CAN SAY A LOT about a place, or nothing at all. Olympic says a lot. It says that this is as good as it gets. Here, astride the pinnacle of excellence, stands the champion. Fitting, then, that mapmakers should borrow the modifier from mythology and stamp it upon this peninsula poking fist-like into the Pacific at the westernmost edge of the 48 contiguous United States. And if the word suits the peninsula, why not recycle it to the peninsula's national park, overlorded as it is by the mountain Olympus, named for the throne room of the Grecian gods?

Other parks may boast of mountains or beaches, but none has a forest to match this.

The park is a throne room in its own right: More than 900,000 acres of icy summits and alpine meadows, rushing rivers and glacial lakes, fog-shrouded sea stacks and surf-fed tide pools; a sanctuary for spawning salmon and rutting elk; a seedbed of spruce and fir and cedar soaring above a rain forest as grand as any in the world. Who knows? Among American landscapes, Olympic National Park just might be better than it ever gets.

For this you can cheer a circumstance of nature and an act of human restraint. The circumstance is water. Offshore the warm surface of the Kuroshio (Japan Current) heats the air, creating weather. Storm clouds scud







ashore. Forced upward by the slopes of the Olympic Mountains, the cooling clouds lose their capacity to retain moisture. And down comes the rain and snow—lots of it. The west side of the peninsula shakes down more precipitation annually than any other spot in the lower 48—an average of 135 inches inland from the coast, more than 200 inches, most of it as snow, near the 7,965-foot summit of Mount Olympus, the peninsula's highest point. Without this accident of ocean storms ambushed by coastal mountains rising practically straight out of the sea, there would be no glaciers here (there are more than 60), no perennially rushing rivers, possibly fewer salmon, and nowhere near the depth of rich alluvial soil needed to nurture champion conifers. That's nature's part in it. But without the intervention of people determined to protect these resources from commercial exploitation, there would be no Olympic Park.

First-time visitors can be overwhelmed by the park's accessible diversities. "You get three totally different experiences for the price of one park," a young woman said one drizzling day in the Quinault Valley. "Rugged mountains, wild beaches, and this spectacular rain forest in between, all of it doable in a day if you don't stray too far from your car." Those who do stray will have the beaches, mountains, and forests mostly to themselves. Ninety-five percent of Olympic Park is statutory wilderness—quite a lot considering it is only 40 miles from a major U.S. city, Seattle. U.S. Highway 101 brackets the park on three sides. From the highway, a dozen spur roads, some unpaved, enter the park for a short distance to end, full stop, at a trailhead. Beyond the trailheads lie 600 miles of paths, lacing the wilderness.

*Fickle as an Olympian god, the park's climate can be ally or antagonist. Abundant moisture feeds the leafy cover where a coyote stares back with wary eye. But frequent assaults by cold, snow, and wind can turn a tree into a bleached and tortured sculpture.*





Beyond the  
trailheads  
lie 600  
miles of  
paths,  
lacing the  
wilderness.

THE ENTIRE PENINSULA WAS RAW WILDERNESS once upon a time, home for at least 10,000 years to Native Americans. Today their descendants reside for the most part along the coast in tribal communities seeking to preserve the Makah, Klallam, Quileute, Quinault, Hoh, and Skokomish cultures.

The first European to sight the peninsula was likely that seafaring Greek, Juan de Fuca, who, sailing for Spain in 1592, imagined he had discovered a waterway that led east across the New World, all the way to the Atlantic Ocean. In exchange for Juan's honest mistake, we get his eponymous strait. As for poking into the peninsula's mountainous interior, that would have to wait for another three centuries and a U.S. Army lieutenant named Joseph O'Neil, whose bushwhacking ascent from Port Angeles to Hurricane Ridge in 1885 would take an entire month (a spur road gets you there today in less than an hour). O'Neil is believed to be the first non-Indian to set foot there, as well as the first individual to advance the idea of an Olympic national park.

But before there could be a park there would be a forest reserve, established by President Grover Cleveland in 1897 and dedicated to the proposition that henceforth on some two million acres—more than half the peninsula—commercial logging would be sharply restricted. As it turned out, "henceforth" lasted only three years, after which time Cleveland's successor, William McKinley, hearkening to the laments of the lumber barons, remanded one-third of the reserve's land back into the wide-open, come-and-get-it public domain. And this was only the beginning of a long, peninsular tug-of-war between the folks who like their conifers straight up, and those who prefer them on the rocks, horizontally merchantable.



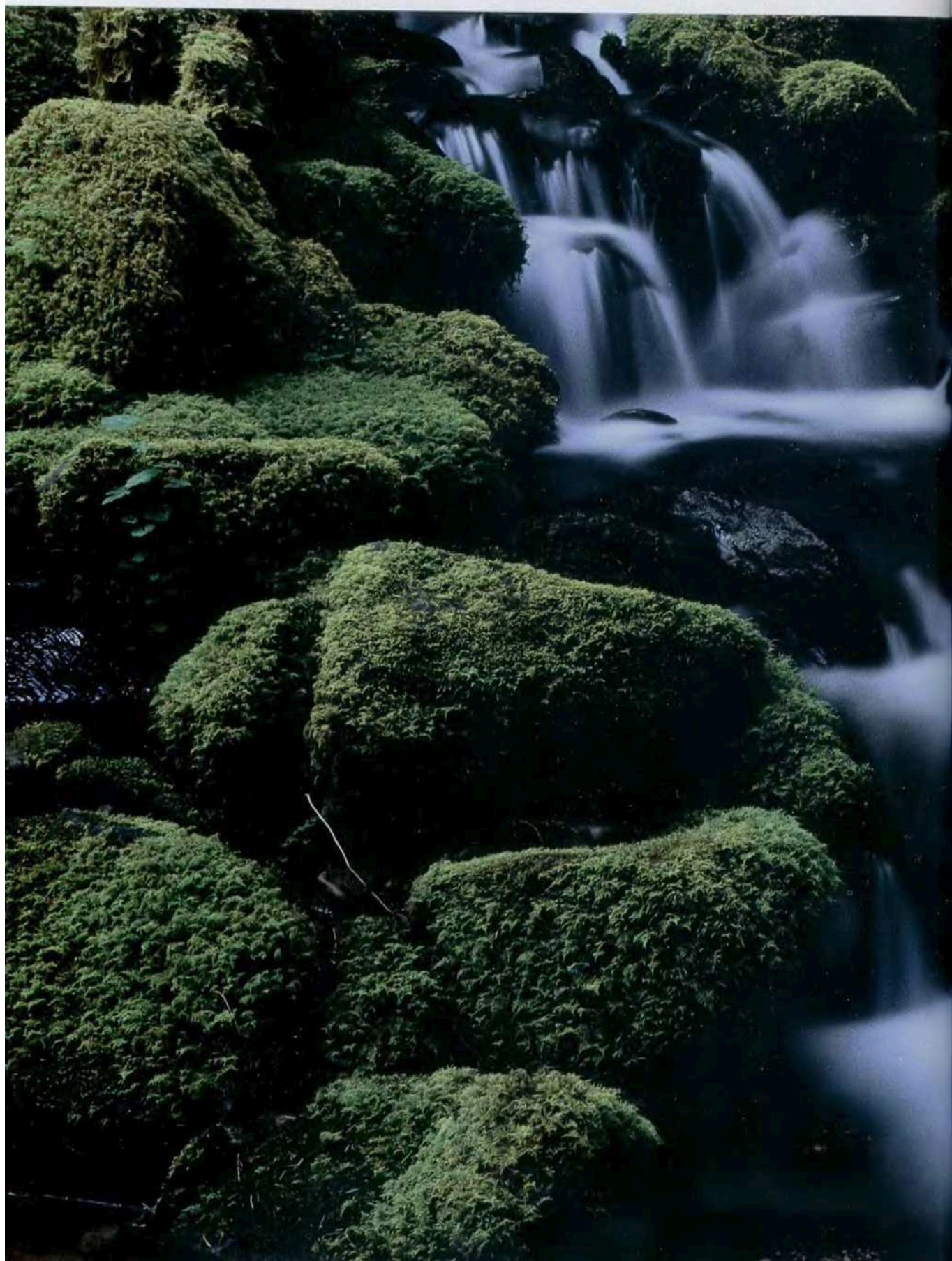


*A brief lifting of fog reveals a Columbian blacktail deer near Hurricane Ridge. Wildlife has room to roam in the park, which covers 922,651 acres. Human contact is minimal: There are no through roads, only spurs to trails for hiking and horseback riding.*



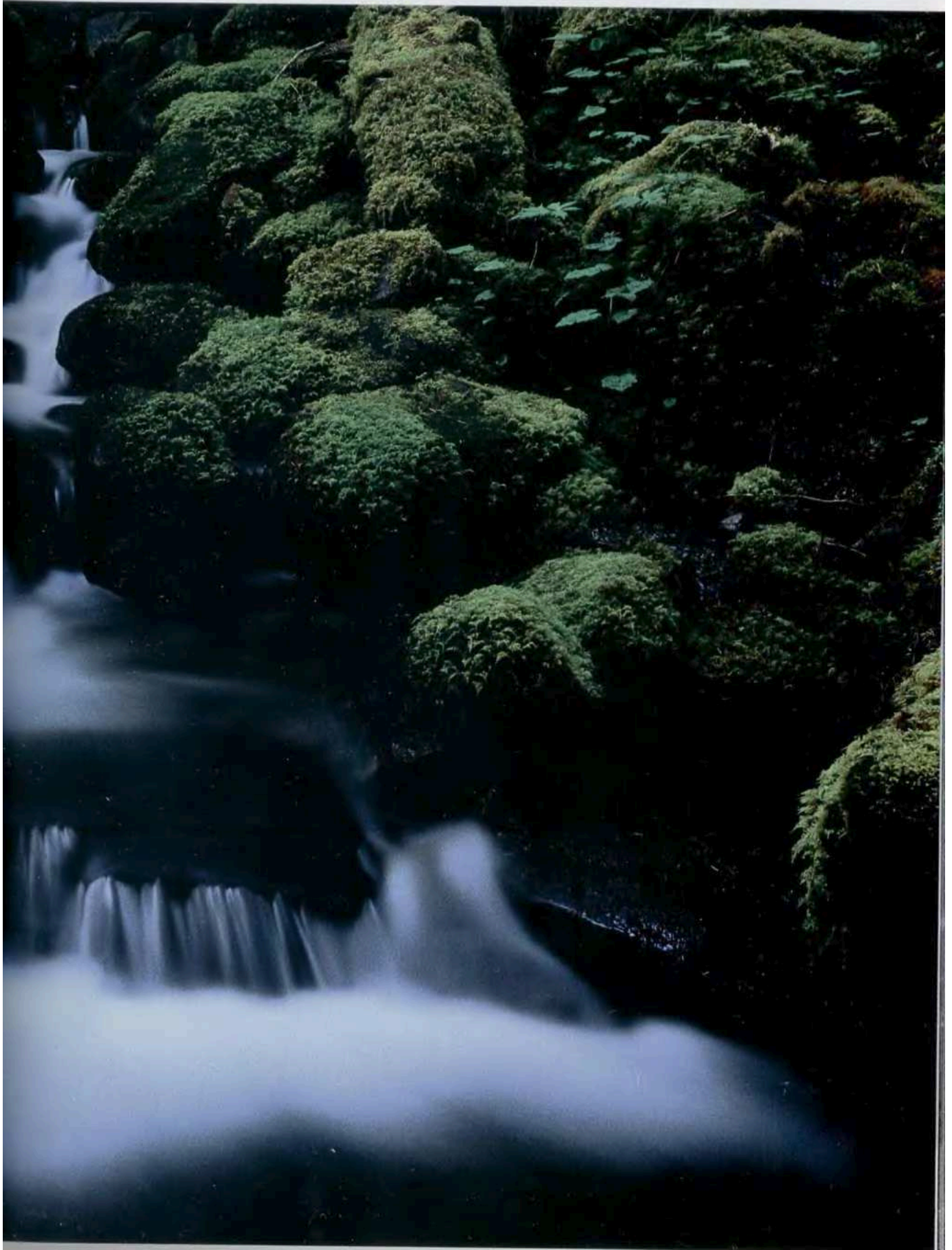
LUSH TEMPTATION

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*Idyllic scenes of snow-fed streams and emerald mosses are too attractive for their own good. Park rangers must guard against poachers who scalp the forest of mosses and ferns for sale to florists and nurseries. More brazen thieves cut down and haul away red cedar trees.*





Keep your eyes to the ground. Here in the understory are species rooted in a floor of rotting wood.

Succeeding McKinley—and countermanding his giveaway—Theodore Roosevelt in 1909 invoked the Antiquities Act to designate part of the forest reserve as Mount Olympus National Monument. But the idea wasn't simply to save the conifers from the loggers. T. R. also hoped to protect the elk from the Benevolent and Protective Order of Elks, whose members fancied the creatures' incisors dangling from their watch fobs.

By the early 1930s conservationists, based largely on the East Coast, were lobbying the administration of Franklin D. Roosevelt to take the monument away from the U.S. Forest Service (an agency then devoted almost exclusively to selling timber) and expand it into a full-fledged park under the National Park Service. In 1937 Roosevelt paid a visit to the peninsula in an open touring car. Three thousand schoolchildren had been rounded up to greet him in front of the courthouse in Port Angeles, and a big sign proclaimed: "Please, Mr. President, we children need your help. Give us our Olympic national park." Within a year, they got it.

OTHER PARKS MAY BOAST OF MOUNTAINS or beaches, but none has a forest to match the qualities of this one. A temperate rain forest, scientists and tree huggers call it, and possibly the finest swatch of botanical intemperance along an evergreen coast extending almost 2,000 miles from northern California to southern Alaska. Mosey by trail or spur road into one of the park's west-facing valleys and, for starters, keep your eyes to the ground. Here in the understory are mosses, horsetail, hedge nettle, sword fern, salmonberry, and sorrel, each species rooted in a floor of rotting wood—an







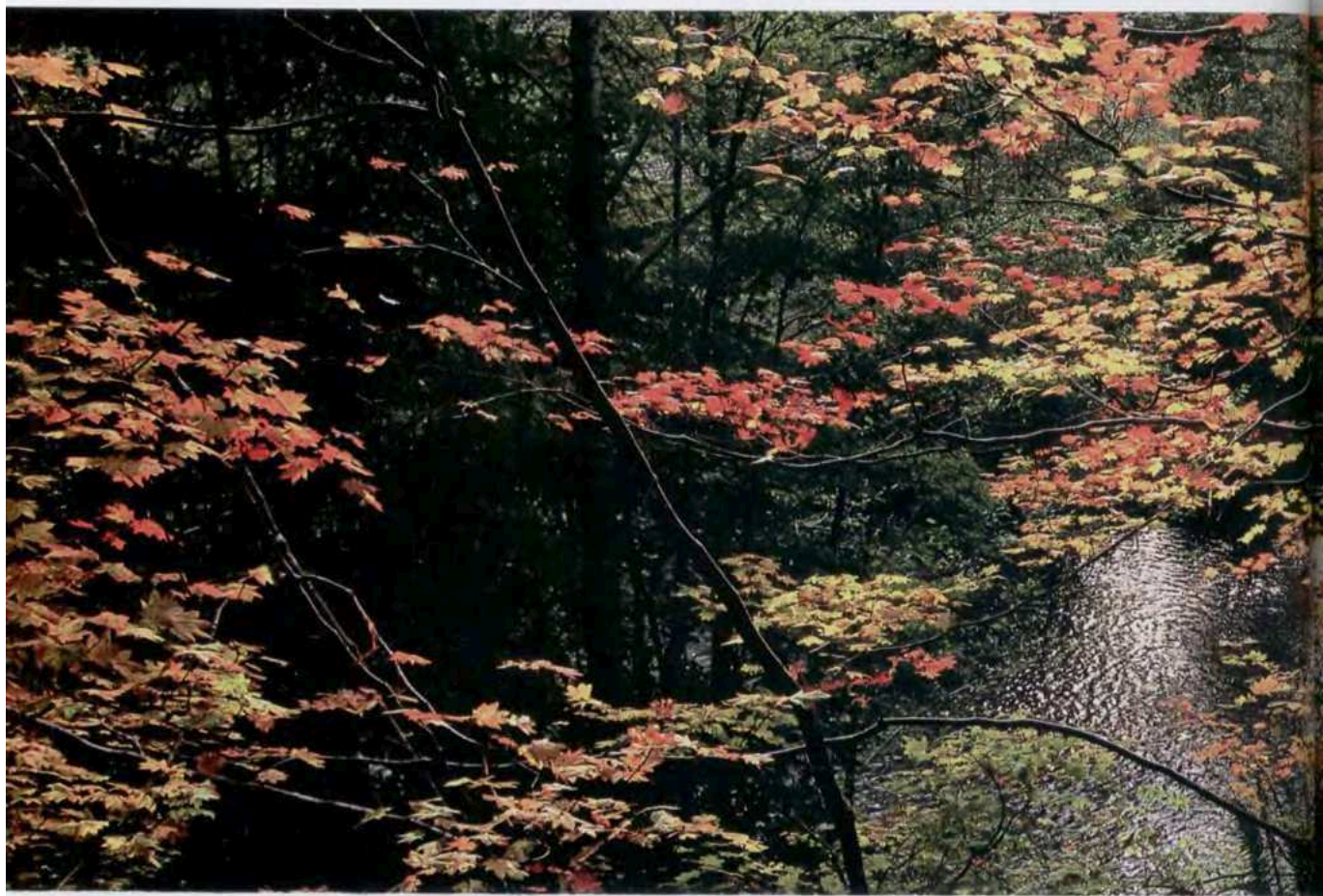
accumulation of fallen trees and organic duff said to be the densest on Earth, exceeding that of any tropical rain forest. Lift your eyes to the midstory, and here are red alder and black cottonwood and vine maples festooned with mosses and other epiphytes. Then put a crick in your neck to behold the venerable columns of the big trees.

It has been said that Olympic National Park and the wilder edges of the Olympic National Forest abutting it are entitled to claim the gold medal for sprouting more champion conifers than any area of comparable size in the United States. Up the Quinault Valley reigns the world's largest western red cedar, with a chest-high circumference of 61 feet and an antiquity that might have seeded it here before Juan de Fuca was chest high himself. A bit farther up the Quinault, hang a left on Big Creek Trail, and you'll encounter the nation's largest yellow cedar. Elsewhere, the park can boast of its world champion subalpine fir and western hemlock, while the national forest registers the world champion Sitka spruce and a Douglas fir that is 302 feet tall. But if you've seen these champs (should you be so lucky), you haven't necessarily seen them all. Other contenders, as yet undiscovered, could well be skulking in the dripping declivities of this arboreal paradise.

I FIRST VISITED THE PENINSULA about 15 years ago, on a journalistic mission to admire not the height or girth of the park's standing giants but rather the volume of wood the timber industry was then cutting from the forest surrounding the park, and the mood of the working people who looked to that cut for their daily bread. As it turned out, their mood was contentious,

*A pup in the dogwood family, bunchberry (opposite) rises only inches from the forest floor, its snowy display framed by ferns. Hardy subalpine firs (above) grow starburst patterns. An old-growth sanctuary, the park harbors trees that are well over a thousand years old.*



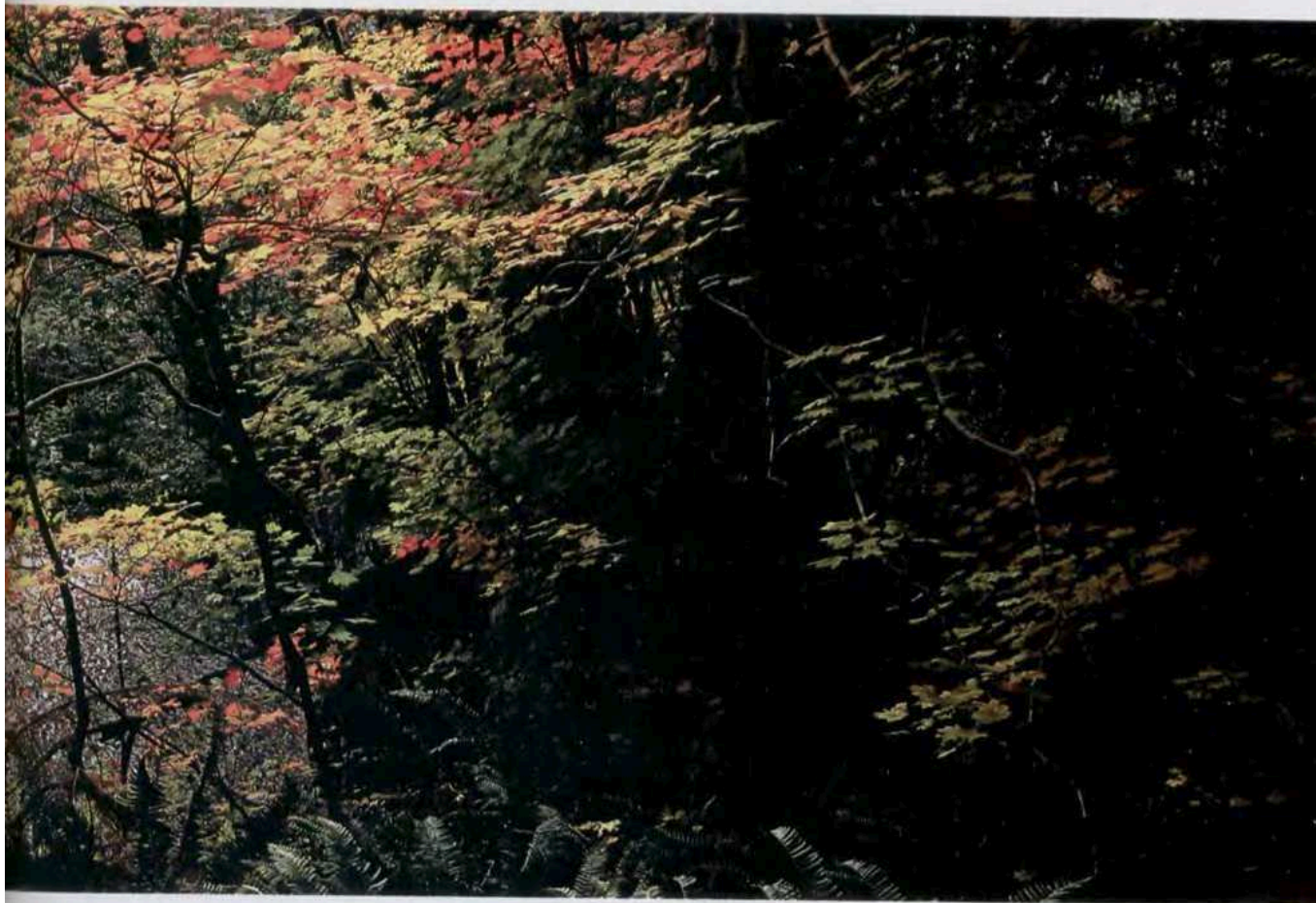


"Contentiousness is behind us now. The park has become a real good neighbor. We're moving on."

for this was at a period in the history of the Pacific Northwest known as the spotted owl wars, and the volume of the allowable cut from the national forest was in sharp decline. The way some of the local folks saw it, it was bad enough that the federal government should get even stingier with logs after the park had already deprived the sawmills of the peninsula's best timber; but now, even worse, for the sake of this goofy threatened owl, the environmentalists were in court putting some state and private timber off-limits too. Over in Forks, a blue-collar community on the west side that billed itself as the Logging Capital of the World, the town clerk enumerated all the set-asides that were reducing the workforce in the woods and at the mills and said, "I don't know. Sometimes it seems that they don't want anyone living out here." I didn't need an interpreter to know what he meant by "they."

Moods and expectations can change over time. In the course of my latest sortie to the Olympic, I circled the park on U.S. 101, from Hoodspoint in the east through Port Angeles and Forks to Quinalt on the southwest. At motels and restaurants along the way, I heard little if any grumbling about the federal presence on the peninsula, though it was evident from the relative scarcity of visible clear-cuts and logging trucks that the timber harvest was still in decline. "The community has been reinventing itself over the past ten years," said Russ Veenema, when I reached him by phone at his office as executive director of the Port Angeles Chamber of Commerce. "There are two big factors that keep us going here. One is the ferry bringing tourists over from Victoria, British Columbia. The other is Olympic National Park."





And in Forks, where the number of motels and B&Bs has doubled in the past decade, a businesswoman said: “The contentiousness is behind us now. The park has become a real good neighbor. We’re moving on.”

SOMETIME LATER THIS YEAR the National Park Service will distribute the draft of a plan describing how it intends to manage Olympic National Park in the future. The plan will examine to what extent, if any, park roads, trails, structures—even boundaries—might be adjusted either to accommodate an increasing number of visitors with all their diverse expectations or to emphasize the protection of the park’s natural resources, possibly even by limiting visitor use with a quota system. The third alternative, of course, is to strike a balance between those two concepts. Following a period for public comment and town meetings, the agency will revise, publish, and prepare to implement a final plan next year.

Olympic National Park Superintendent Bill Laitner is hoping the public will speak up loud and clear. “This is one of the nation’s most treasured places,” he says. “It doesn’t belong to the Park Service or the federal government. It belongs to the American people, and Americans ought to have a huge say in how we manage their park.”

Stay tuned.

*Artists might draw inspiration from vine maples dressed in autumn hues along the Sol Duc River. The river itself draws fishermen enticed by such species as coho salmon, which, fighting through rapids, swim more than 50 miles upstream to their spawning grounds.*

**EXPLORE THIS OLYMPIC CHAMP** with travel tips in our online extra. Then join our forum on park conservation and the timber industry and download Olympic wallpaper from one of America’s most spectacular landscapes at [nationalgeographic.com/magazine/0407](http://nationalgeographic.com/magazine/0407).



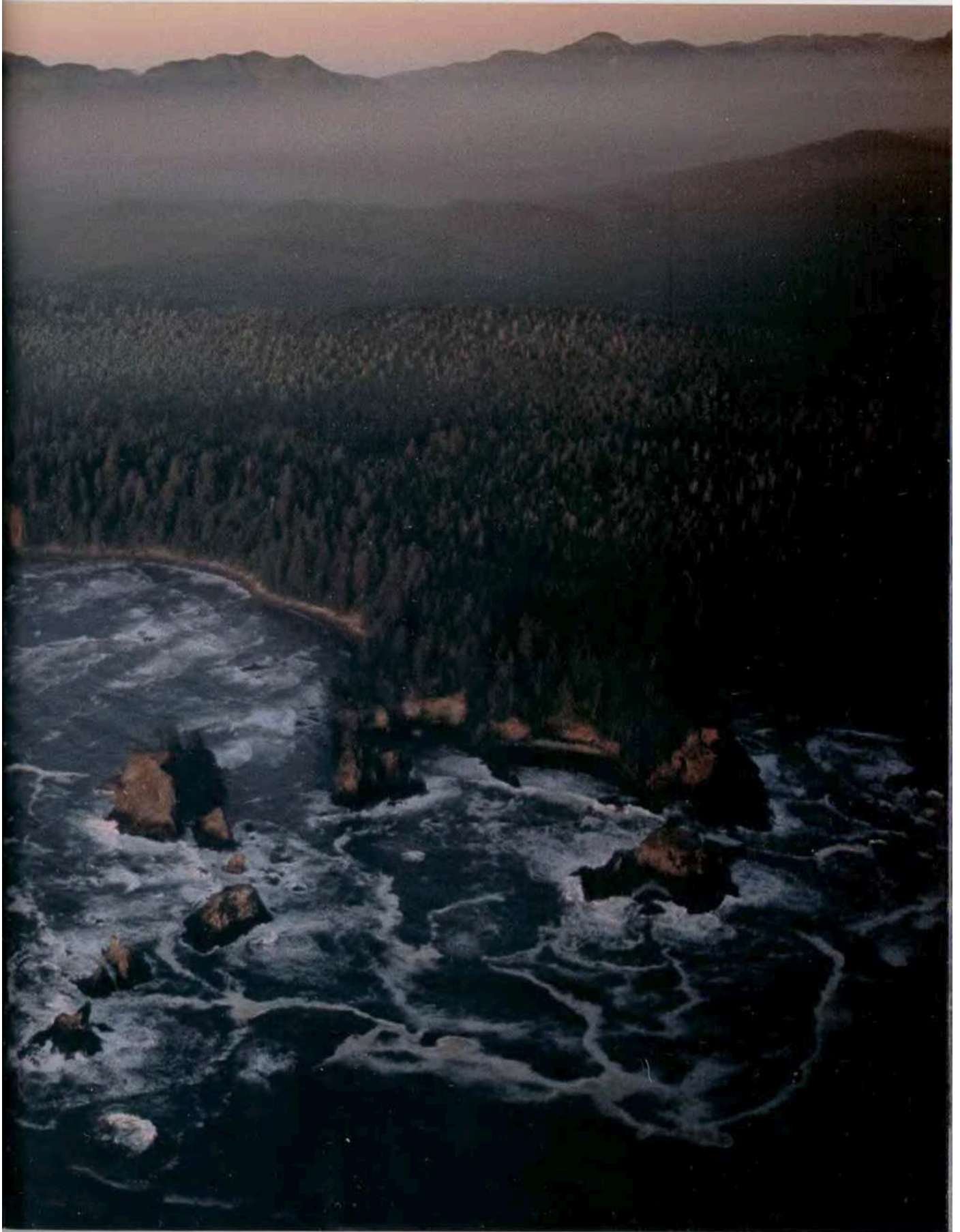
LAND'S END

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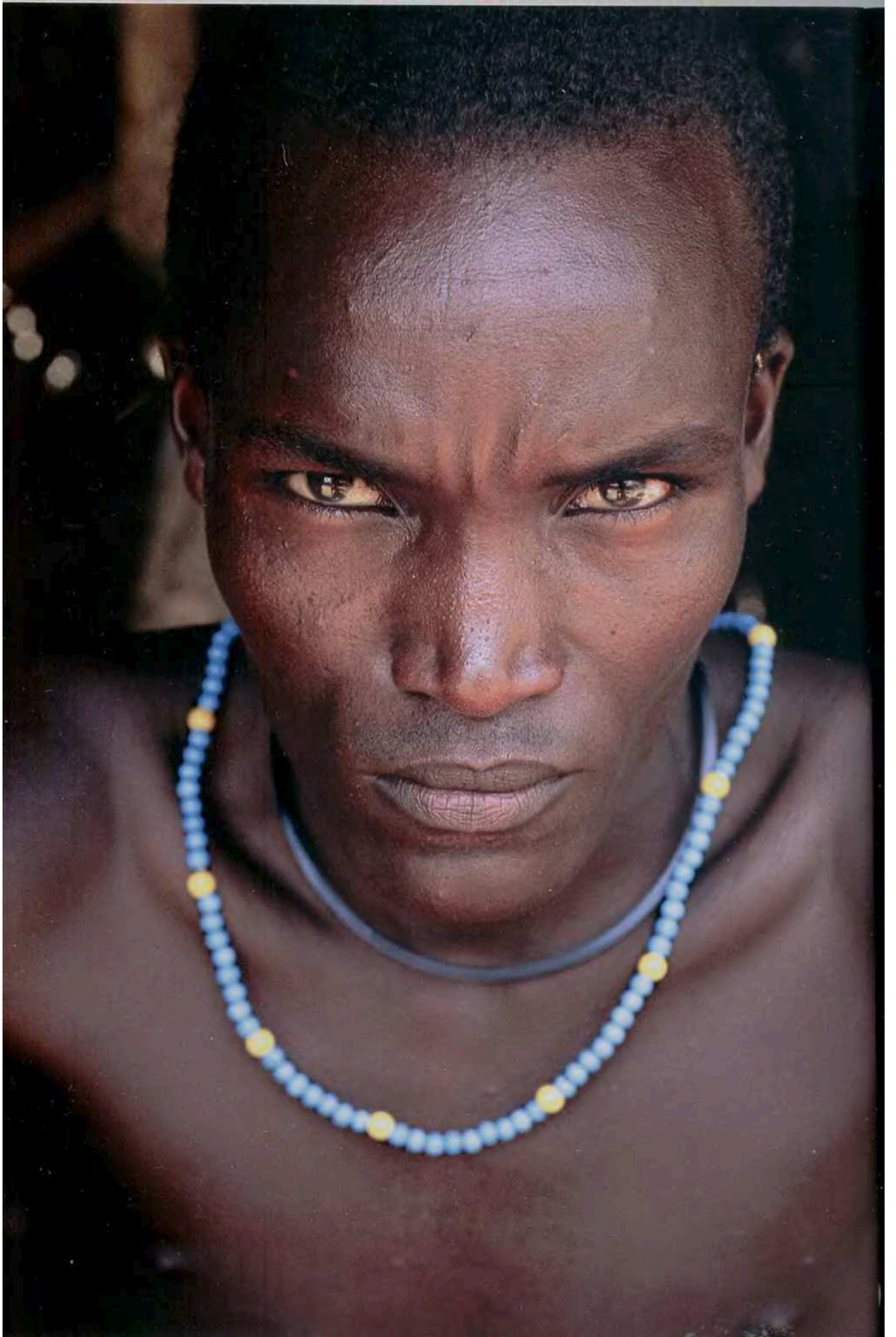




*Stubborn remnants of an ancient coastline, sea stacks tower above the churning tide at Shi Shi Beach. Endowed with a dramatic seashore, thick forests, and muscular peaks, the Olympic scores a gold—shining bright among the nation's premier parks. □*









HUNTING FOR  
**GLORY**

WITH THE BARABAIG OF TANZANIA

BY DEMETRA AOSPOROS

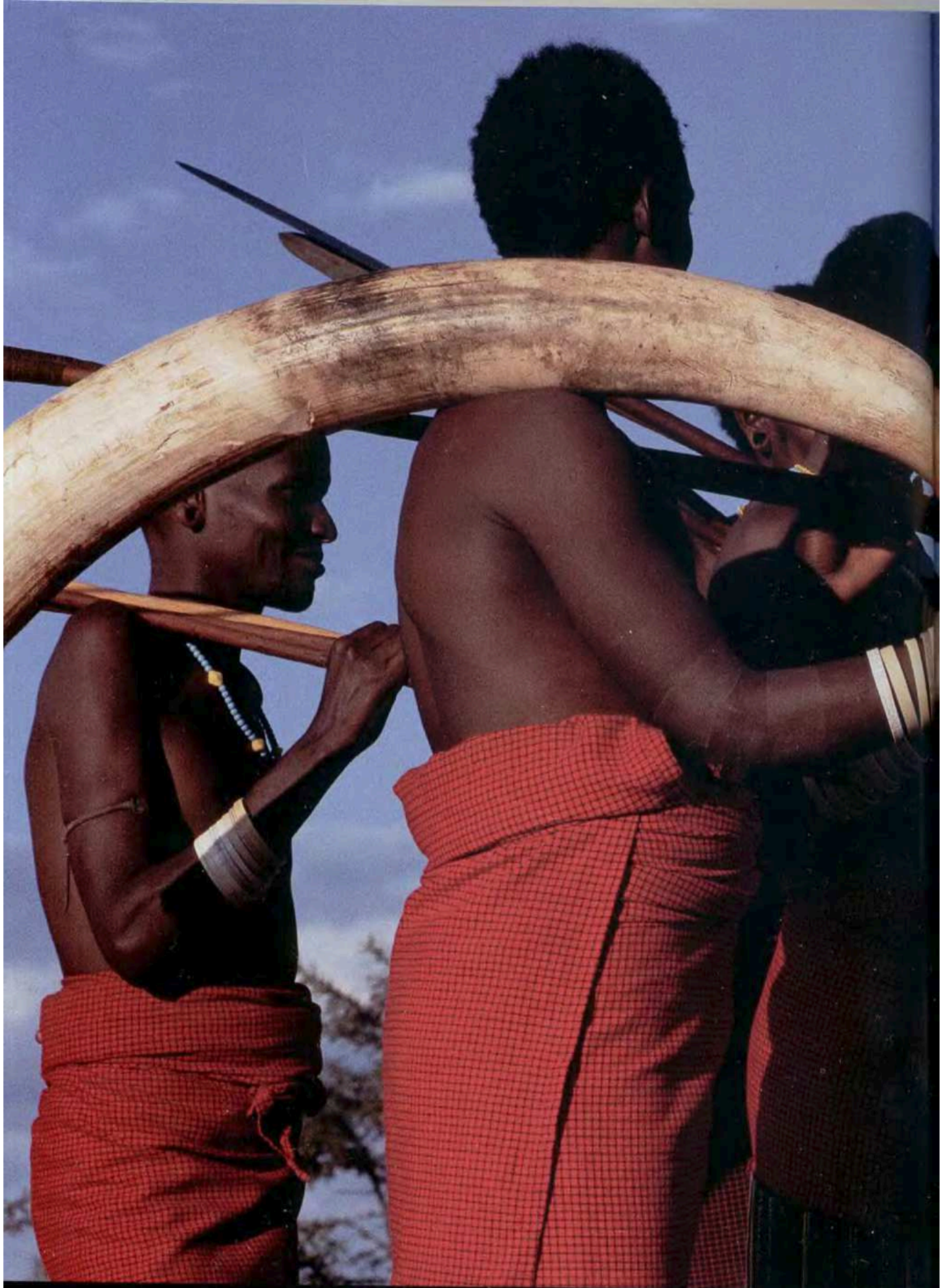
NATIONAL GEOGRAPHIC STAFF

PHOTOGRAPHS BY GILLES NICOLET



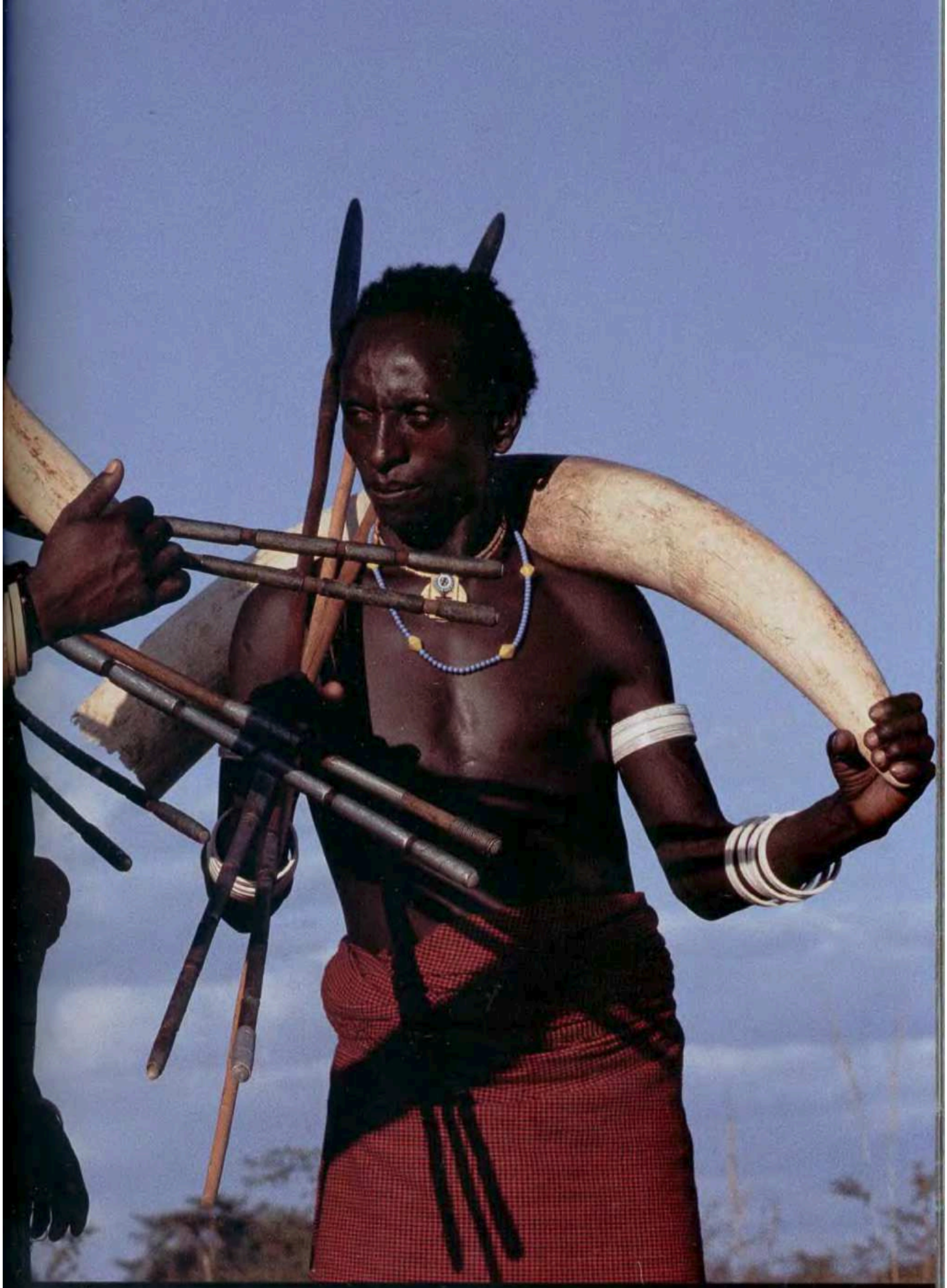
*Steely eyes reflect the unflinching courage of warrior hunters who battle elephants by hand.*



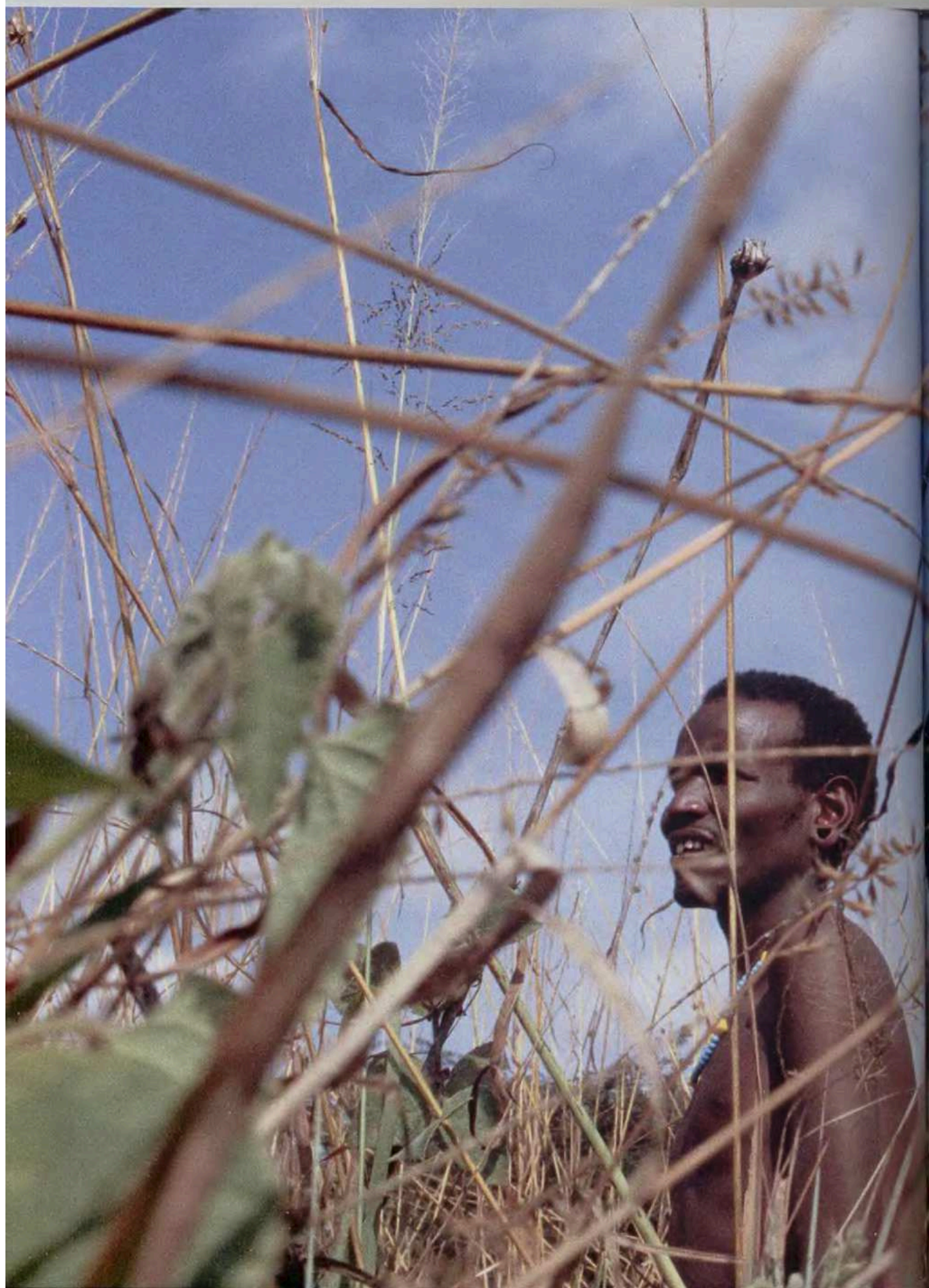


*Returning home with a windfall of ivory, Barabaig men shoulder tusks taken from an elephant found dead in the bush. Tusks are usually taken not for profit but as proof of a kill, though in this case the hunters didn't need to use their razor-sharp spears.*



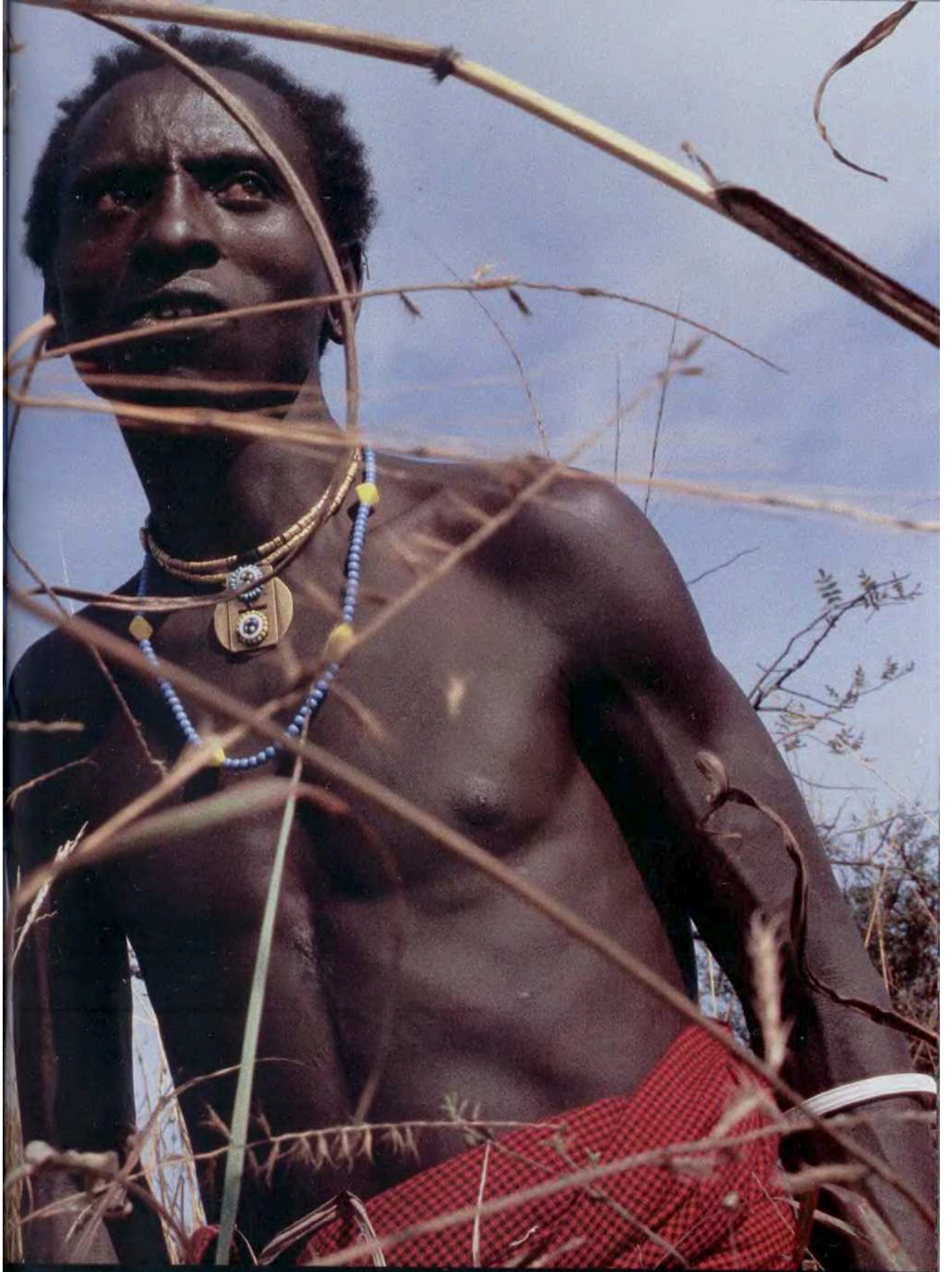






*Senses on high alert, the hunters stalk an elephant sighted after days of searching. The men momentarily drop back to await orders from the kamatalogot, or mother of the hunt, at right. He formulates a strategy of attack, and signals the right moment to make their move.*









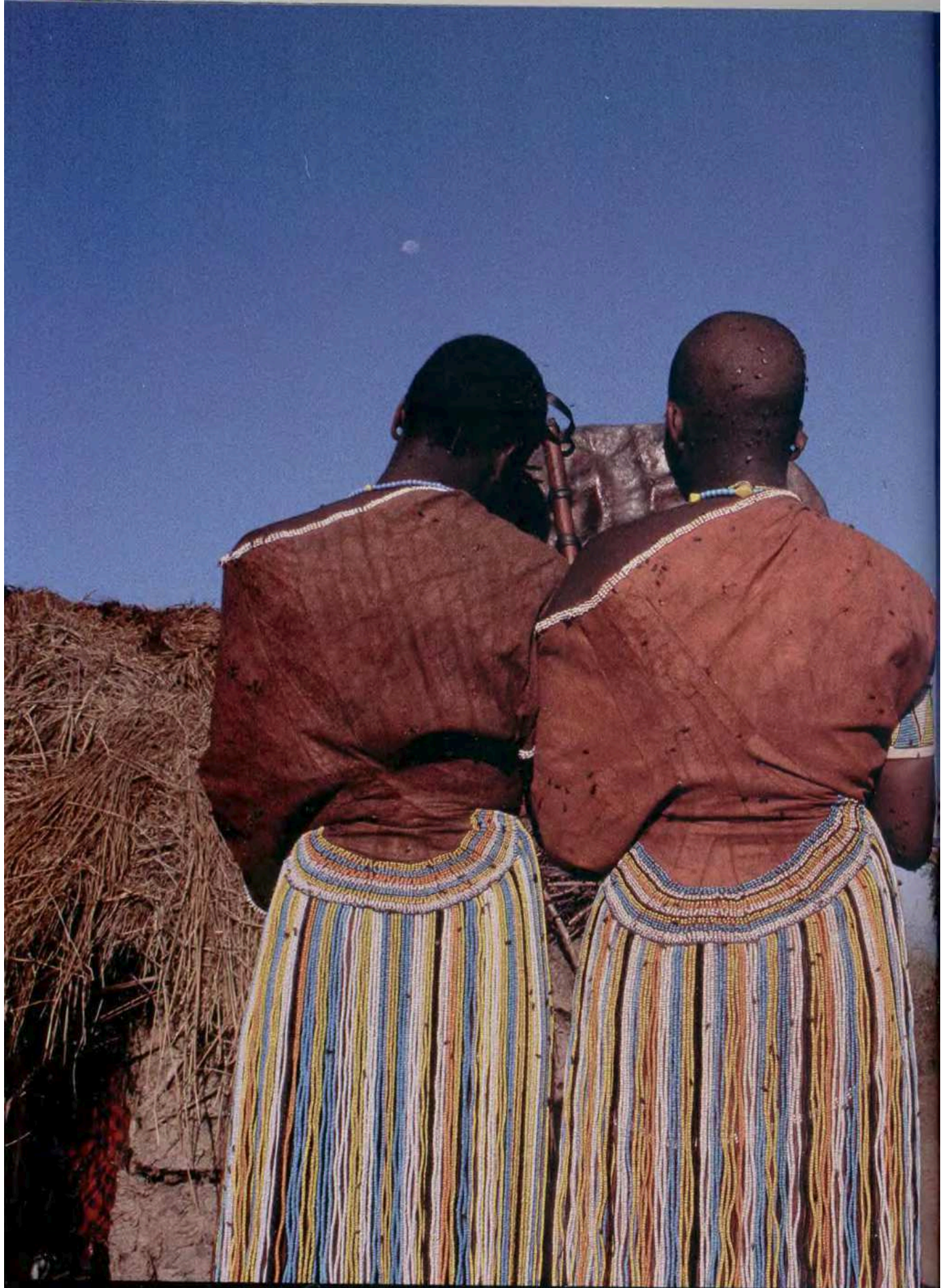
*Rushing in for the kill, the hunters heave spears at their quarry, which is hidden in the thick brush.*

*The danger of losing life or limb, either from the enraged elephant or another hunter's weapon, is very real. (Gilles heard reports that three hunters were killed during his time with the Barabaig.) At this crucial moment the men are exhausted, for the ritual is meant to test their endurance as well as their courage. They walk 12 hours a day and eat nothing for the duration of the hunt, which can last a week or more. Water is allowed, but only once a day. "If God realizes how much you suffer," explains one, "he might protect you and provide something for you to kill." The wounded elephant flees and the hunters give chase, following its blood trail. By the time they catch up with it the next day, it is already dying, and they quickly dispatch it. Soaked with sweat from the long chase, a hunter reclaims his spear (right). Only the first two men to spear the elephant will be hailed as heroes. Finally the hunters remove the tusks (top right), leaving the rest to scavengers.*



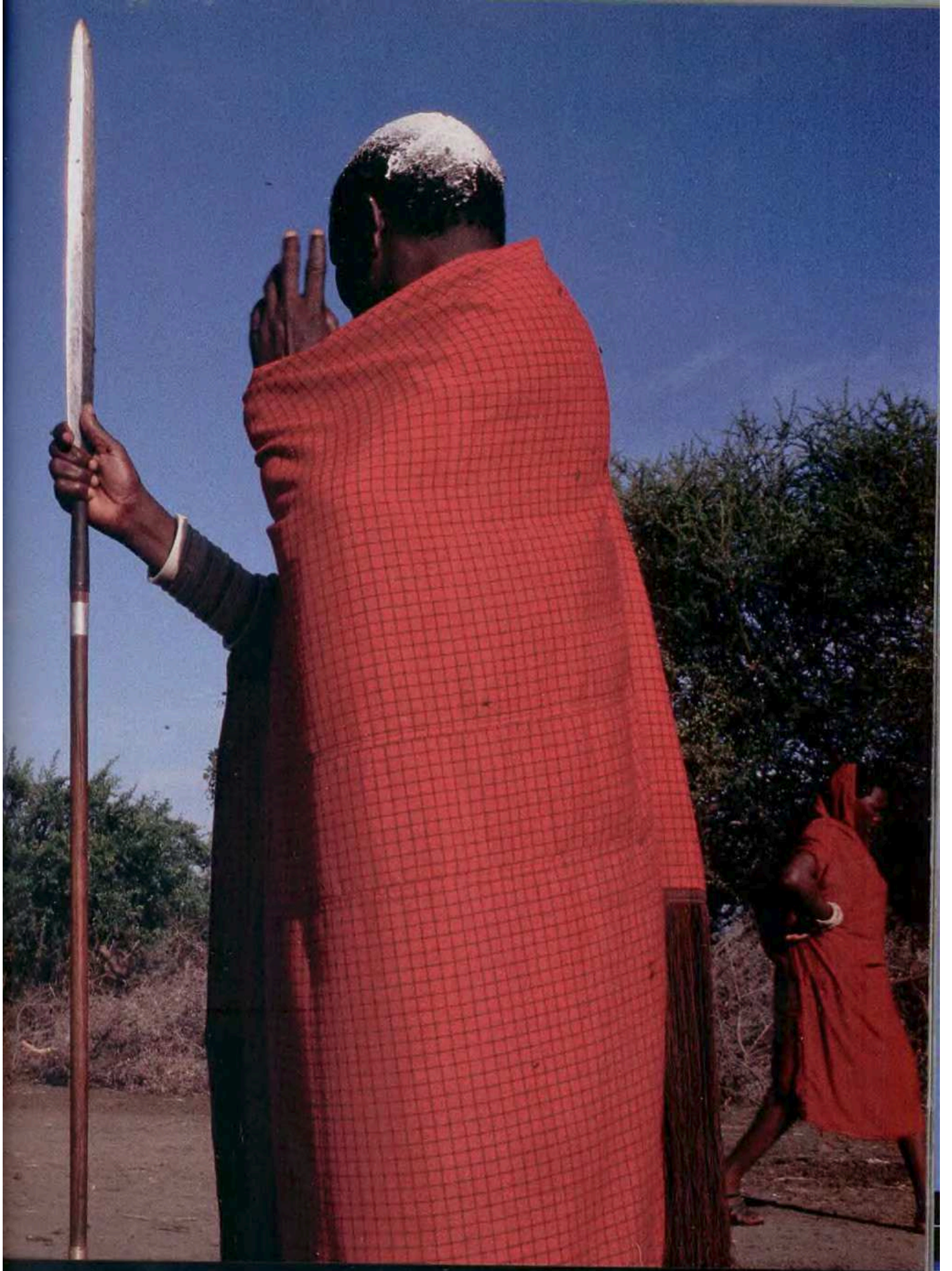






*Returning a hero, a new ghadyirochand travels to homesteads to sing his kill song—which describes his deeds—and be anointed with butter, signifying a blessing by the spirits. On such a visit, unmarried girls sing a heartfelt song of praise into the hero's shield.*









*Having proved himself worthy of a woman's love, a hero is rewarded with a sabotchka, an intimate ritual in which a girlfriend presents him with a belt of woven fibers from a baobab tree (above). Making the belt takes weeks, and the hero wears it like a medal of honor.*

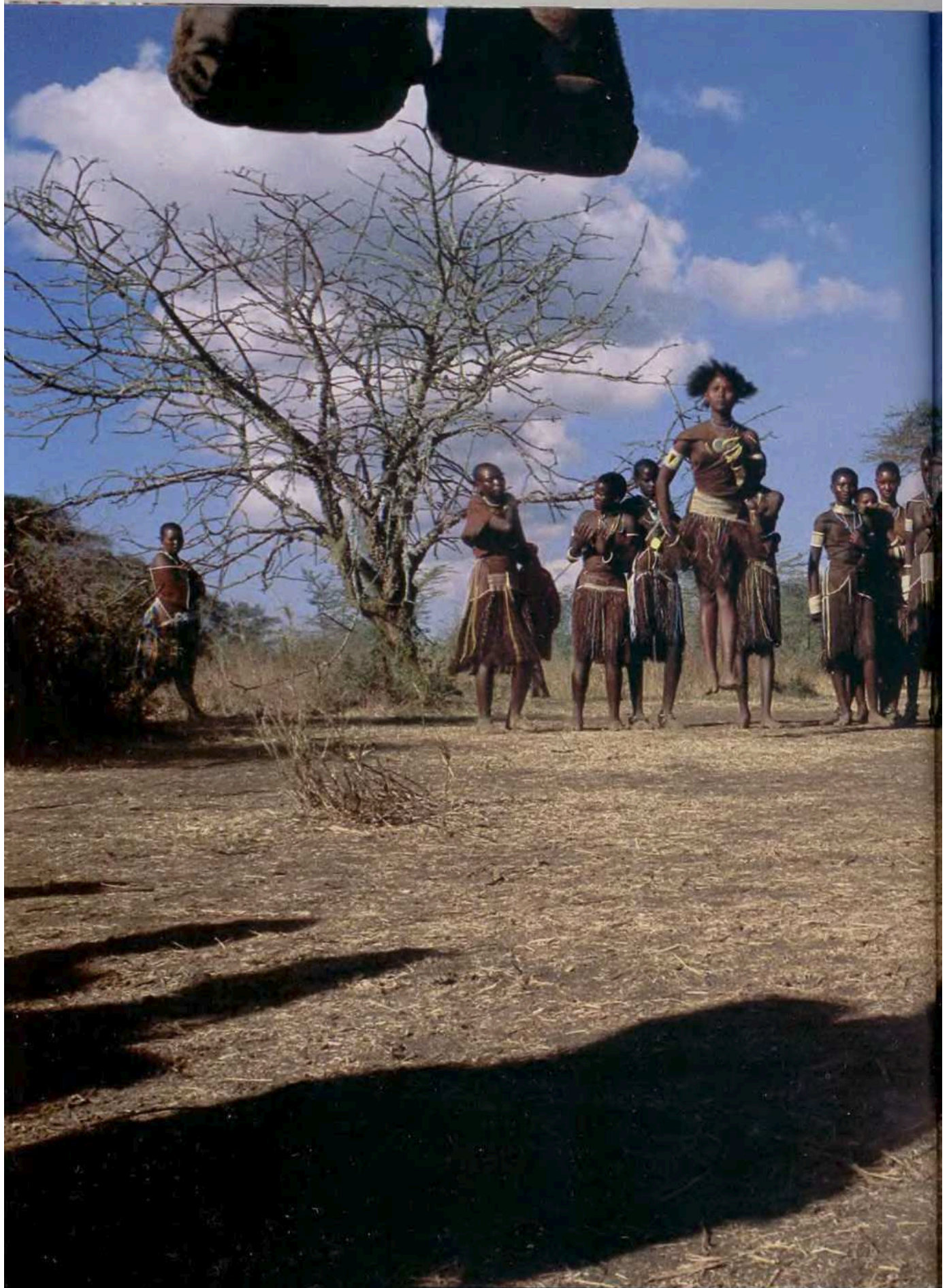
*Killing an elephant or lion shows that a hero stands ready to defend the tribe, and earns him economic rewards as well. For months he visits the homesteads of relatives and others, requesting gifts of livestock. At each stop he will sing his kill song and be decorated with butter (top right). Heroes can collect dozens of cows, goats, and sheep on these rounds. The size of a man's herd determines his status, so acquiring livestock is paramount—even if it entails dangerous hunts. "If you are rich," says one boy, "all the girls will love you, and you will be respected."*

*Other facts of Barabaig life are imparted to young adults at a dangass, a secret meeting held deep in the bush (right). An elder presides over the formal gathering, instructing the youth in tribal customs.*










*Jump-starting a traditional dance, young Barabaig leap into the air as high as possible while keeping their bodies rigid. With men on one side and women on the other, such dances are a kind of flirtation reserved for large gatherings, in this case a funeral.*









 *Garnering the attention of a superstar, a hero (above, at left) mingles with giddy girls at the funeral. A girl of his choice will become the hero's female counterpart, receiving the same honor and wearing similar regalia—like this girl bearing traditional facial scars (right). "She is the first fan among all the fans," says one hunter. "Being a hero's girlfriend is like a precious gift."*

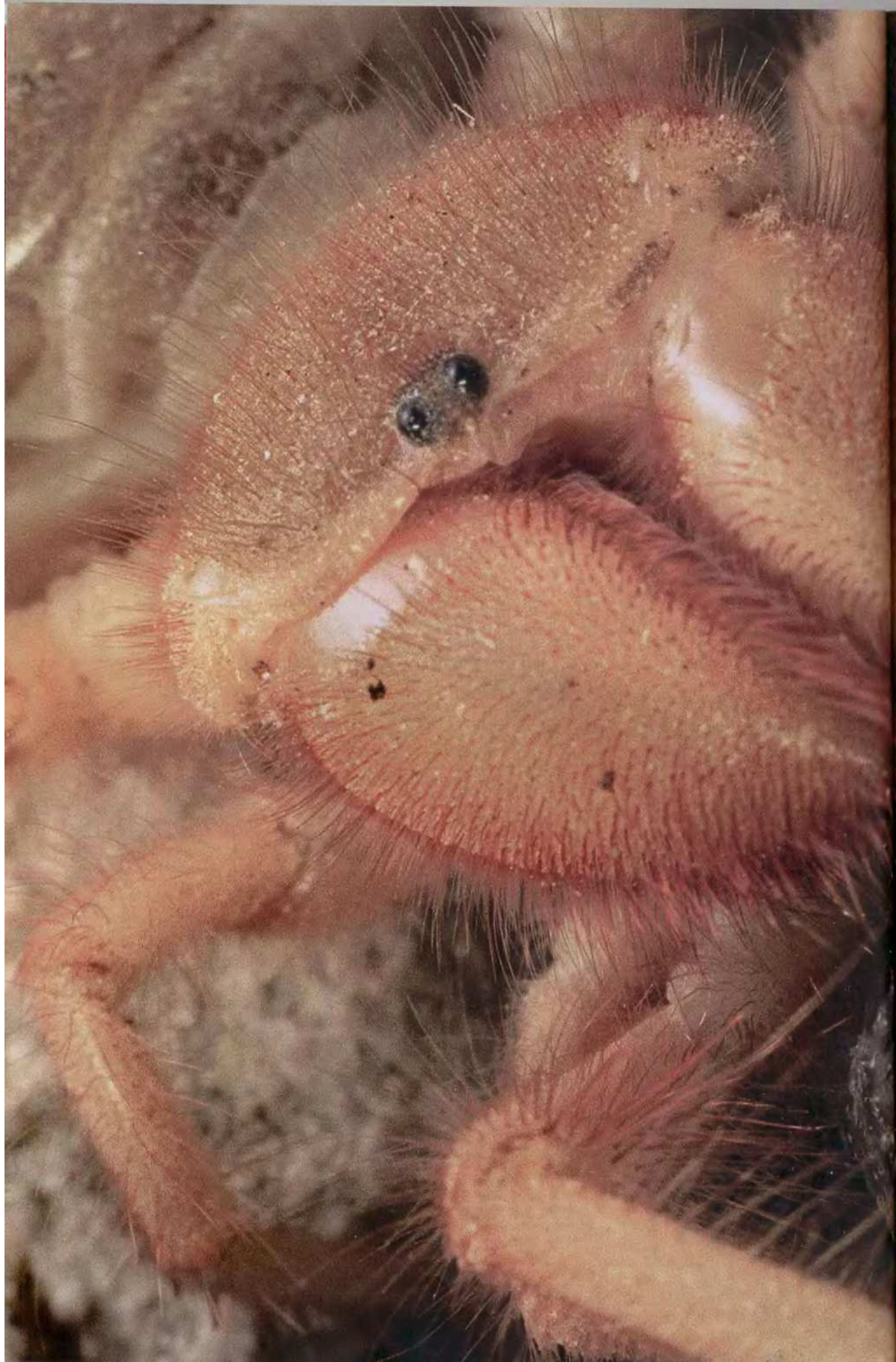
*No one knows exactly how many elephants Barabaig hunters kill each year, but the number is relatively small. (Gilles, one of the few Westerners to witness a hunt, thinks the annual kill may total a few dozen.) Conservationists agree that the traditional practice poses no threat to Tanzania's robust elephant herd, estimated to exceed 100,000. But like other indigenous peoples, the Barabaig are under pressure to abandon age-old ways. While the elephant's future in Tanzania appears secure, the Barabaig hero may soon become an endangered species. □*

**YOUR VIEW** Should the Barabaig be allowed to kill a limited number of elephants? Share your opinion at [nationalgeographic.com/magazine/0407](http://nationalgeographic.com/magazine/0407).

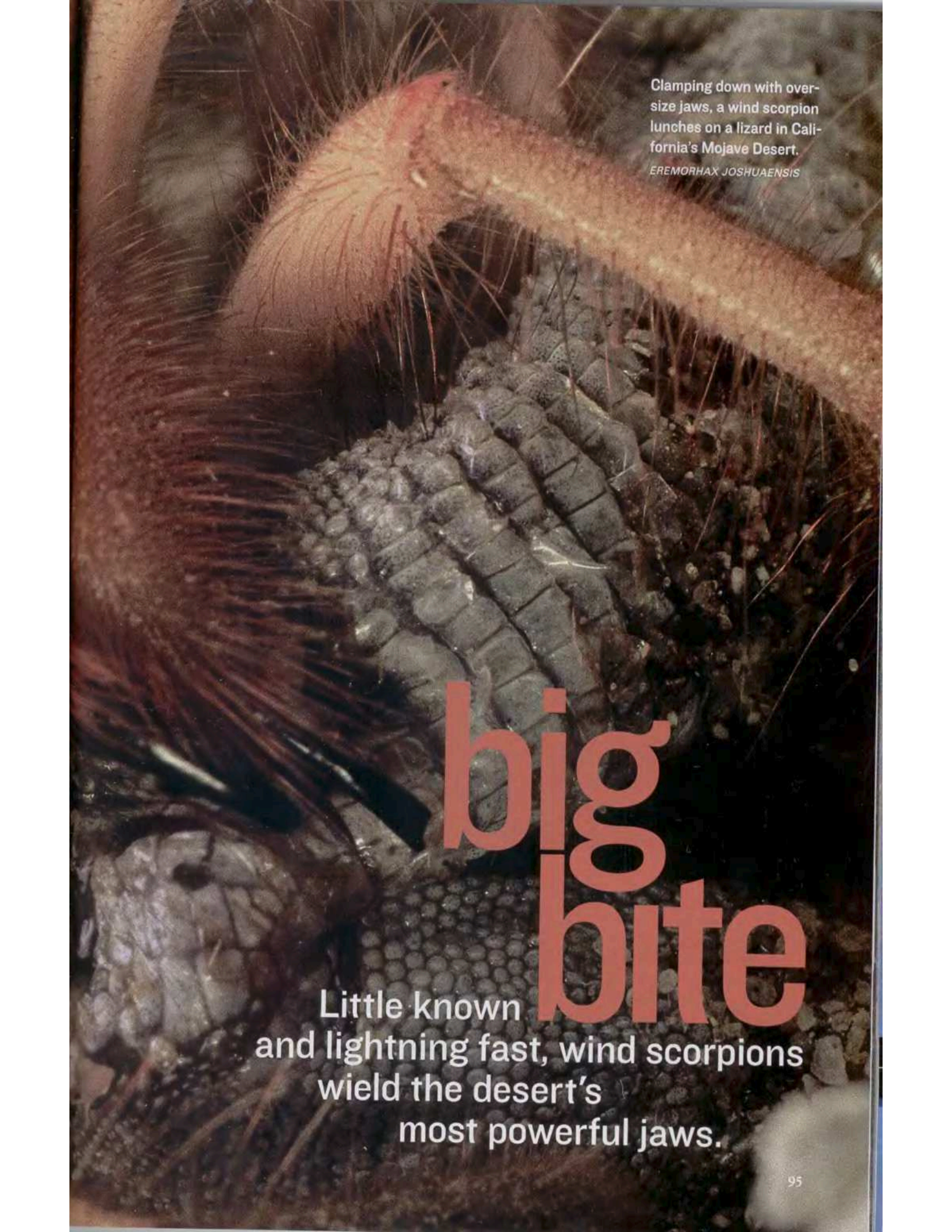












Clamping down with over-size jaws, a wind scorpion lunches on a lizard in California's Mojave Desert.

*EREMORHAX JOSHUAENSIS*

# big bite

Little known and lightning fast, wind scorpions wield the desert's most powerful jaws.





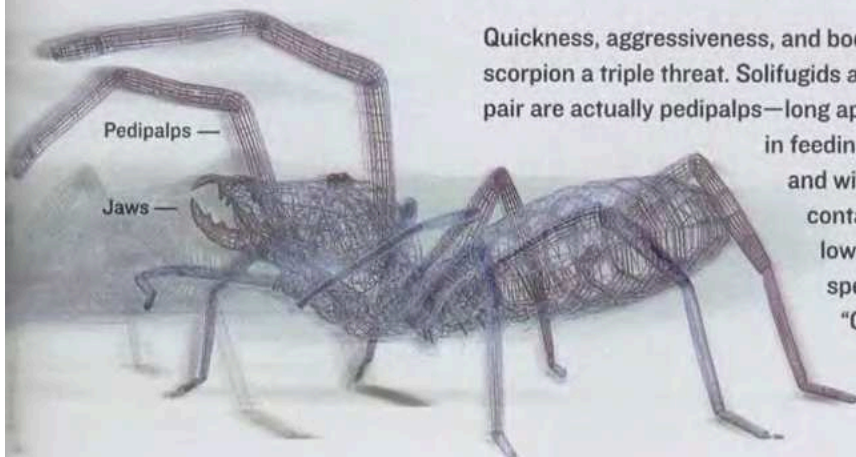


## Text and photographs by Mark W. Moffett

**A**s the sun rose over the desert in Israel, a bizarre little creature stared at me, then rushed back to its burrow. With beady eyes, a hairy body, and jaws that bulged like Popeye's forearms (left), it was something from a nightmare. I had approached it with caution since wind scorpions, though not venomous, can inflict a painful bite on humans—and death on their prey. Zealous carnivores, they attack insects, rodents, lizards, snakes, and small birds, seizing them with jaws that can reach up to a third of their body length—among the largest for their size in the animal kingdom. Wielding those jaws like a combination pincer and knife, they chew their victims into pulp with a sawing motion. They then exude an enzyme that liquefies the flesh, which they suck into their stomachs.

Not actually scorpions, these predators are solifugids, members of the Arachnida, a class that includes spiders, mites, ticks, and true scorpions. Sometimes known as sun spiders, and called camel spiders in North Africa and the Middle East because of their humped profile, wind scorpions weigh as much as two ounces and can have leg spans exceeding five inches. Most of the 1,100 species are nocturnal. Racing over the sand in the dark like super-charged dune buggies, they seem to know no fear.

LEFT AND BELOW: *GALEODES* SP.



Quickness, aggressiveness, and body-crunching jaws make the wind scorpion a triple threat. Solifugids appear to have ten legs, but the first pair are actually pedipalps—long appendages used as sensory organs in feeding, fighting, and mating. The length and wide spacing of the back legs, which contain more segments than those of fellow arachnids, maximize flexibility and speed. And then there are those jaws: "Ounce for ounce," says University of Tampa biologist Fred Punzo, "they deliver one of the most powerful bites in the animal kingdom."

ART BY GREGORY CHEVALIER AND YANN GOUMENT









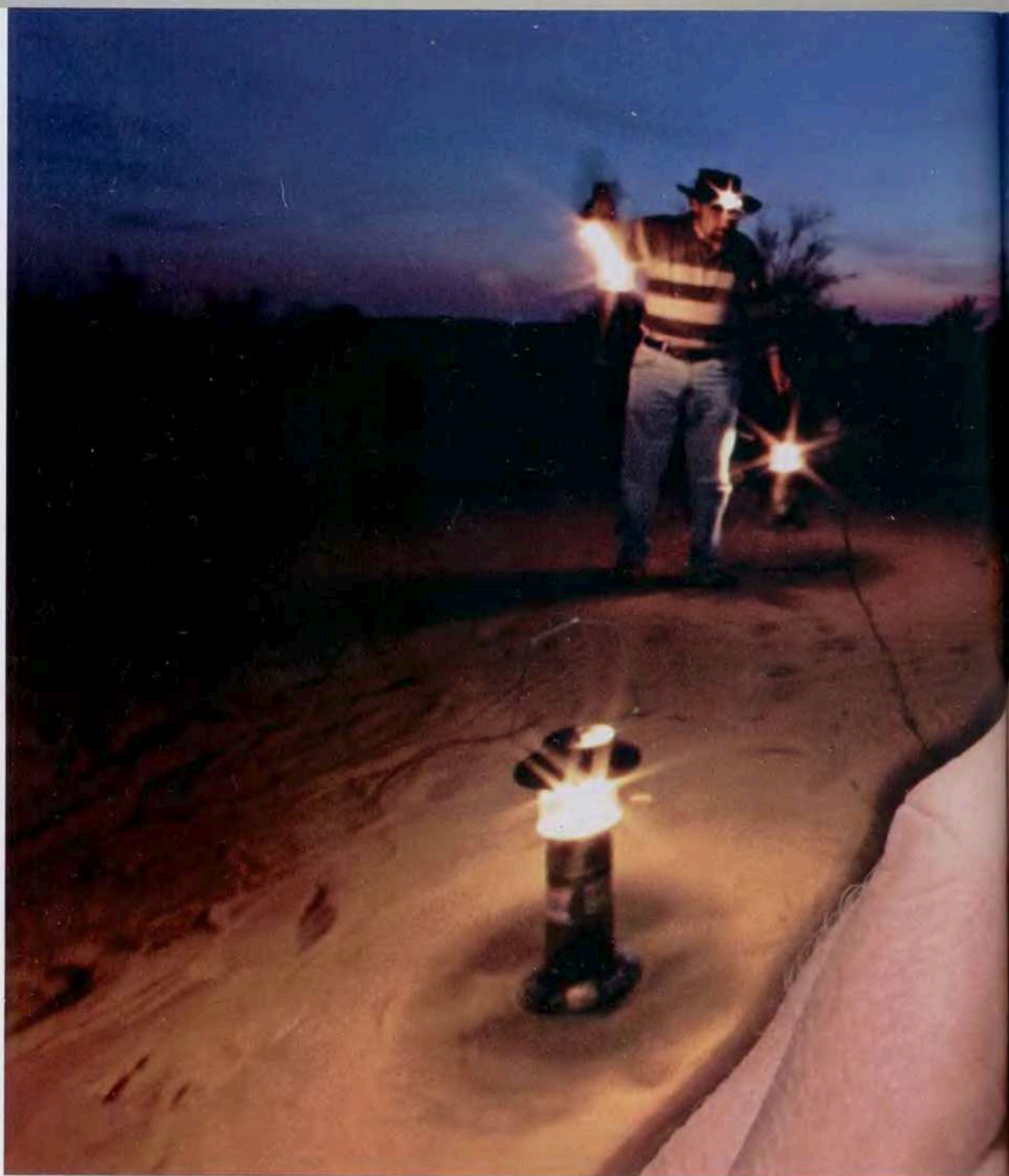
## For the male, mating is a gamble: She may end the courtship—and his life.

Like everything else in their lives, sex for wind scorpions is fast and ferocious. In Iran, I blocked off a patch of desert for wind scorpions I had captured. A male (opposite, at top) gingerly approached a female, stroking her with his pedipalps. He then lunged at her so violently that he tore her body and damaged her legs before mating (top). If given the chance, the female might have preferred him as a meal, not a mate. In California, a female consumed her failed suitor's head (above). Motherhood seems to be the creatures' only respite from aggression. In some, like this Arizona species (below), the mother stands guard over her eggs and later her newborns. The violence starts early: Young may devour their siblings.

TOP AND LEFT: *GALEODES* SP.; MIDDLE: *EREMOCOSTA TITANIA*; BOTTOM: *BRANCHIA* SP.





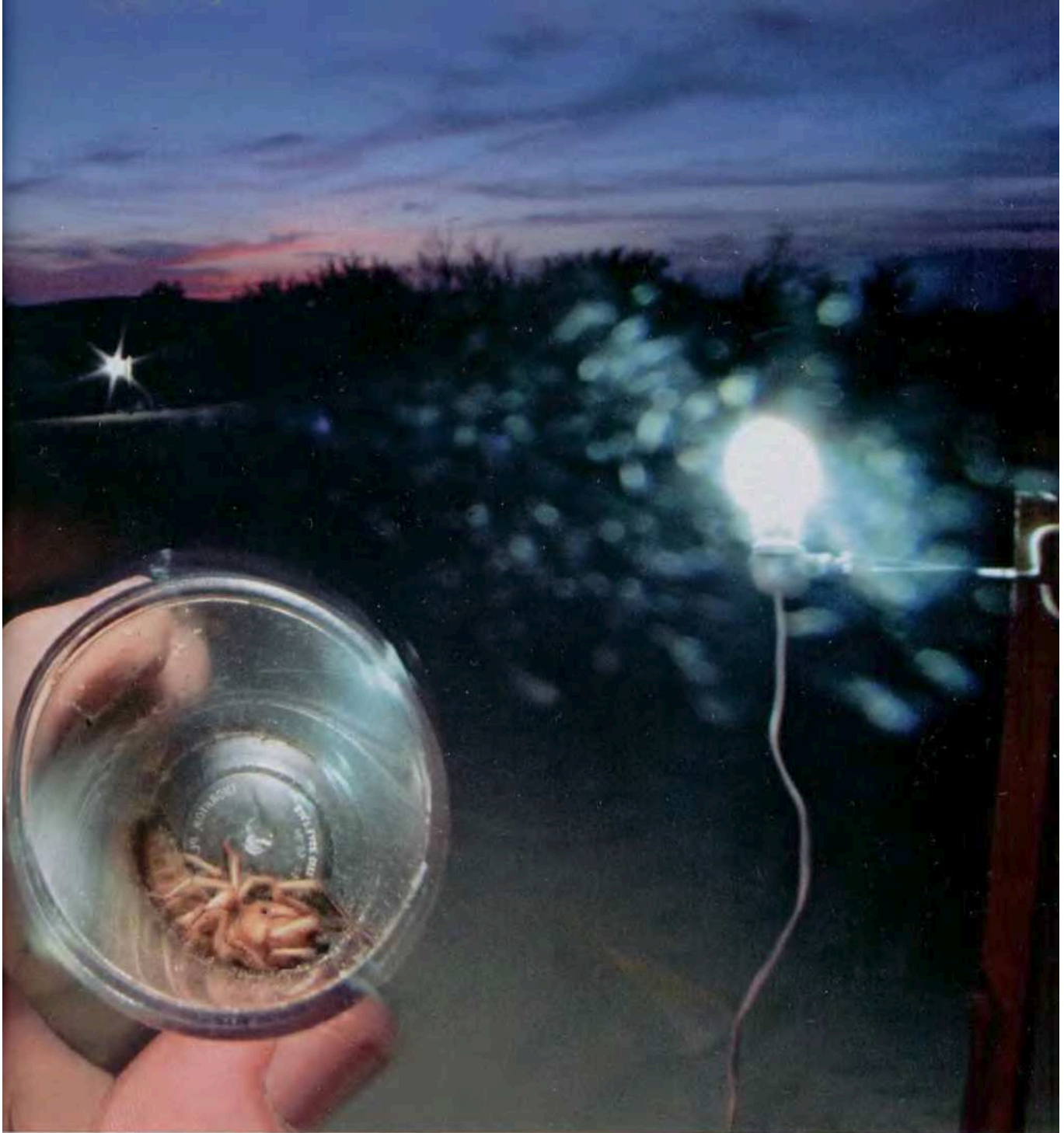


In the Mojave Desert, I examined a newly captured specimen in a jar (above) as Warren Savary put out lanterns to collect other wind scorpions that rushed in to dine on insects attracted by the light. Warren, a wind scorpion researcher in his spare time, has been studying and describing several new solifugids, including a species in a new genus we encountered in Baja California. Kellar Autumn (right), a biologist at Lewis and Clark College in Portland, Oregon, put a wind scorpion through its paces on a treadmill. Kellar hopes to find out how such cold-blooded nocturnal creatures manage their energy as they race about on cold desert nights. Except for the cockroach, no insect or spider is known to run faster. □

ABOVE: *EREMORHAX JOSHUAENSIS*; RIGHT: *GALEODES* SP.

**SCOPING UP WIND SCORPIONS** For Mark Moffett's best, worst, and quirkiest tales from the field—as well as a wind scorpion photo gallery and a listing of resources and related websites—go online to [nationalgeographic.com/magazine/0407](http://nationalgeographic.com/magazine/0407).

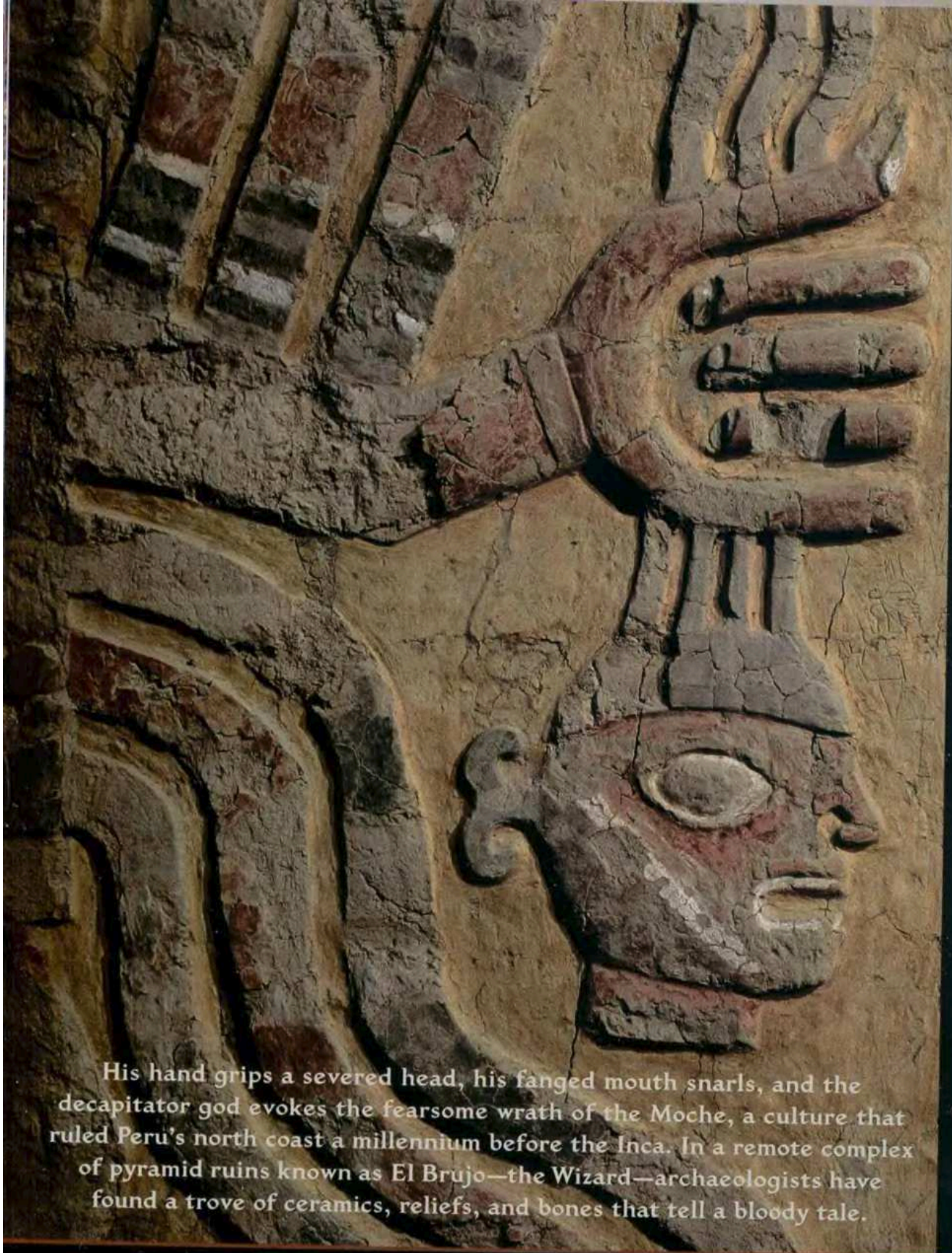




They're so quick as they pursue a gecko or tarantula, they seem to fly like the wind.



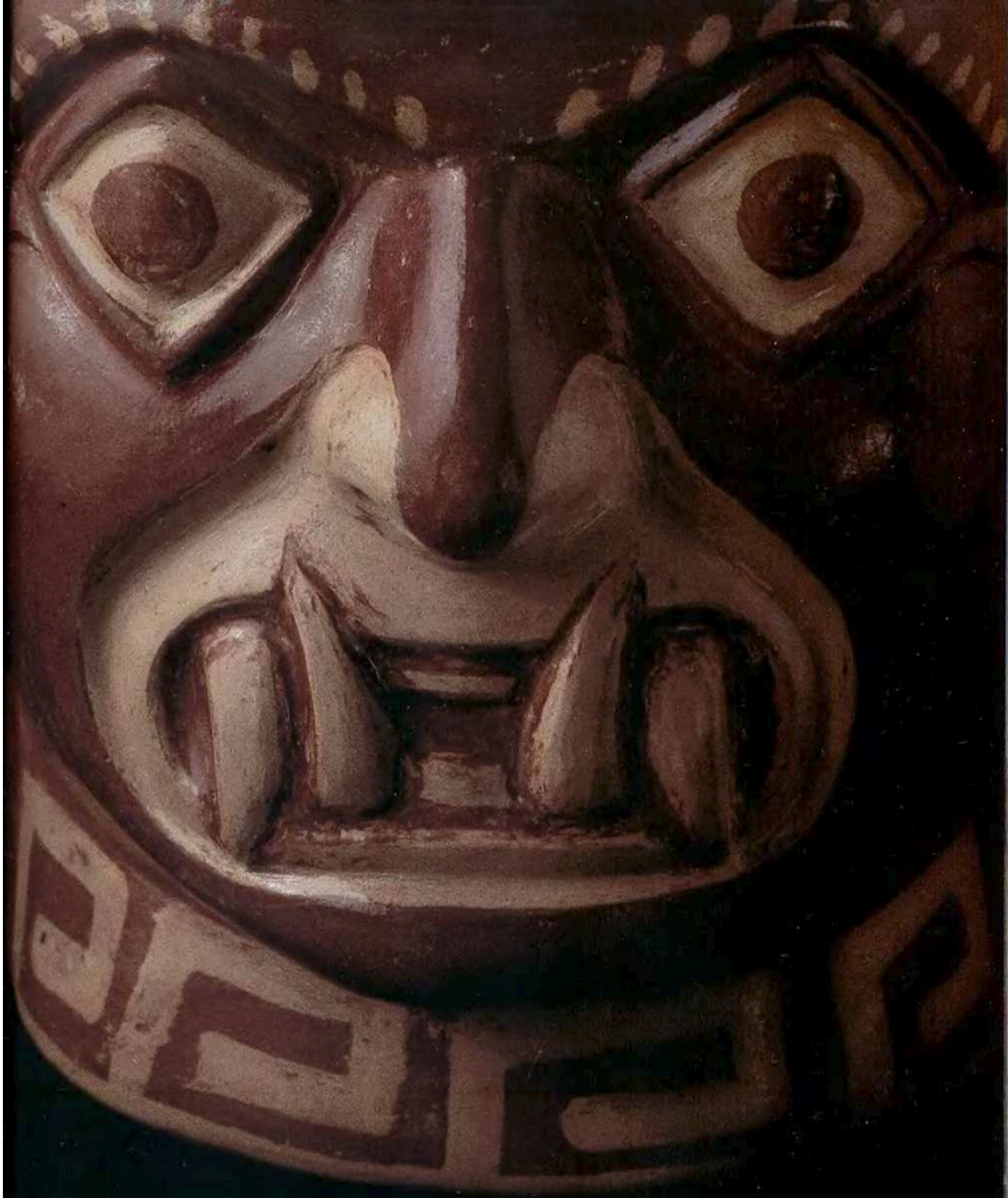




His hand grips a severed head, his fanged mouth snarls, and the decapitator god evokes the fearsome wrath of the Moche, a culture that ruled Peru's north coast a millennium before the Inca. In a remote complex of pyramid ruins known as El Brujo—the Wizard—archaeologists have found a trove of ceramics, reliefs, and bones that tell a bloody tale.

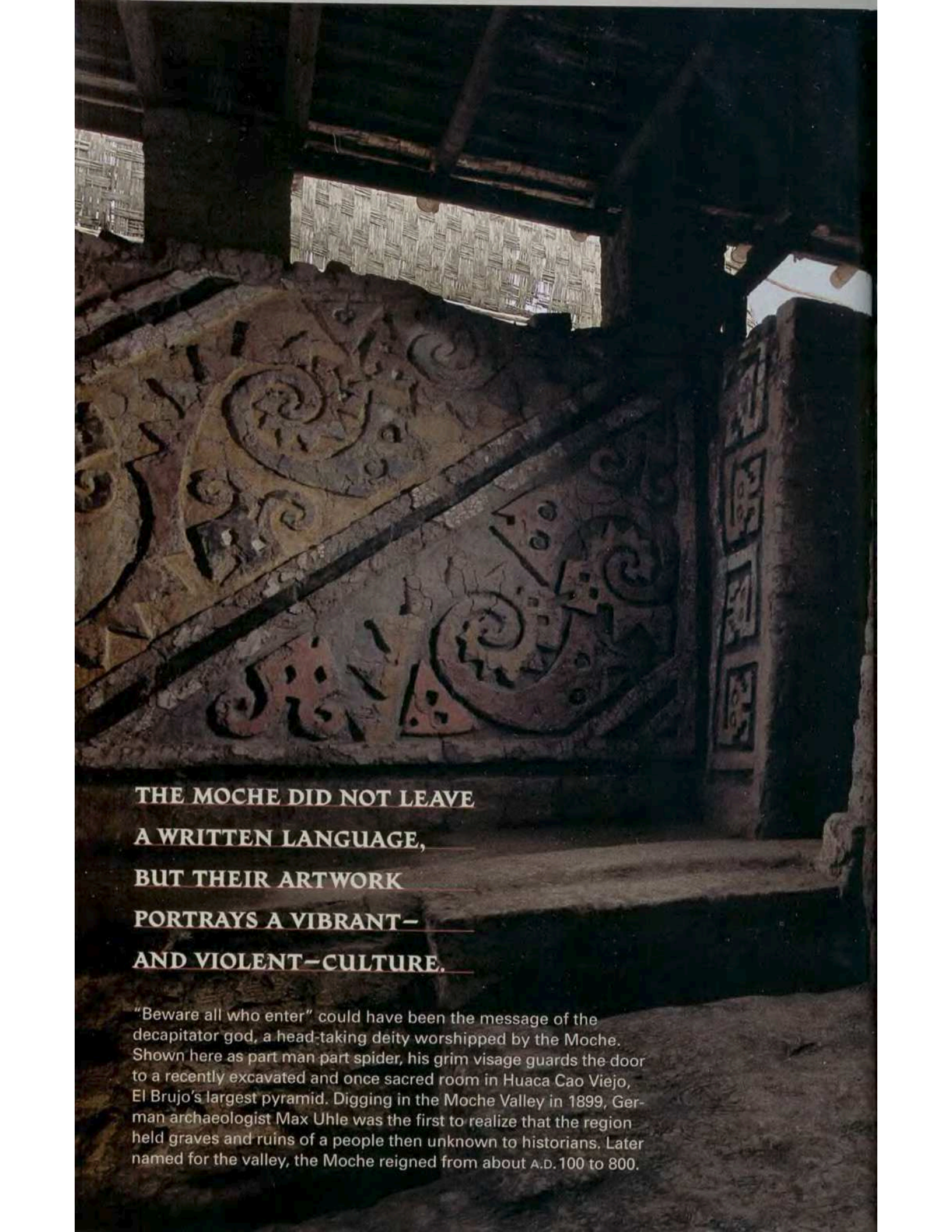
# PERUVIAN TEMPLE OF





DOOM

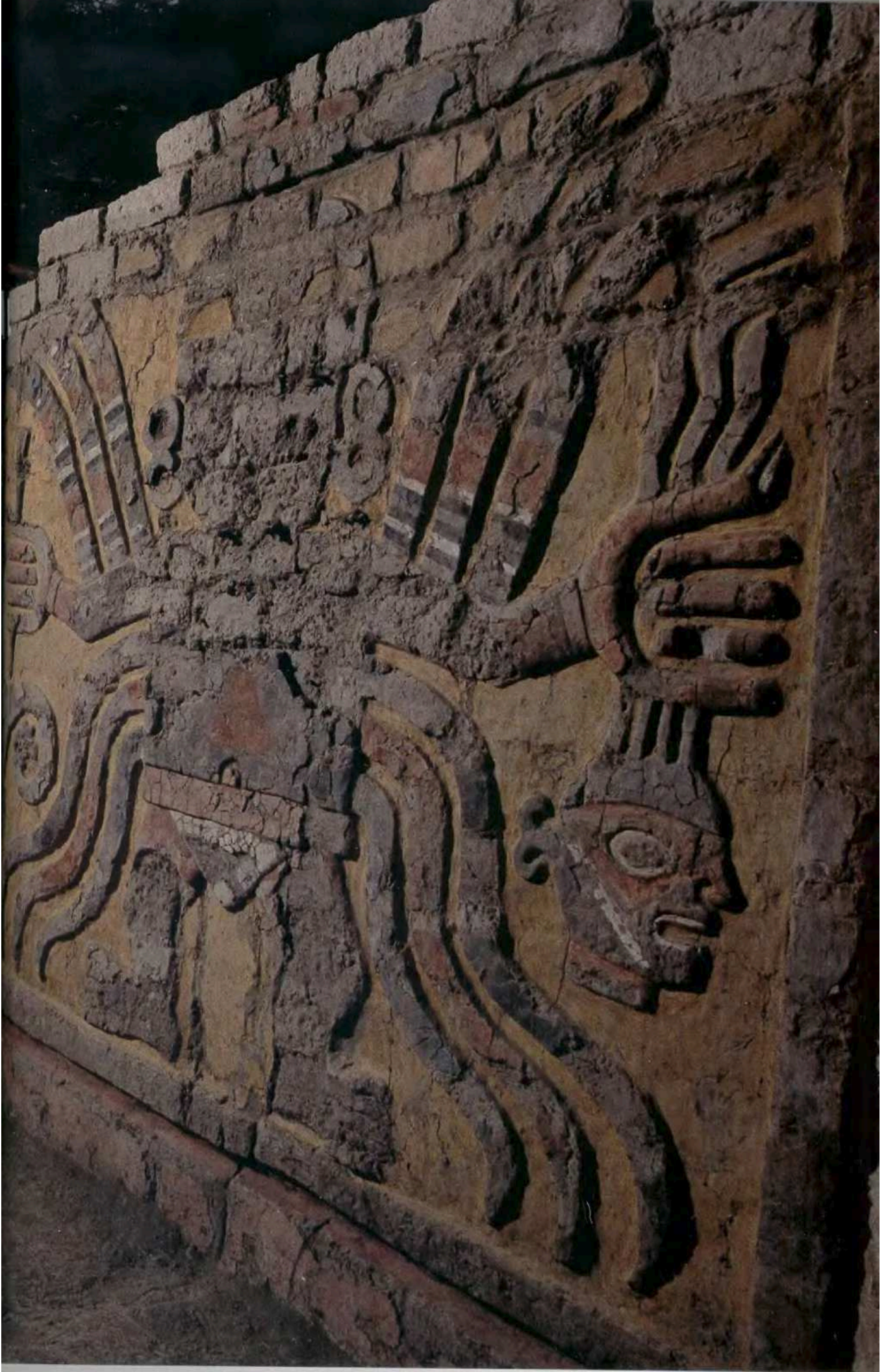




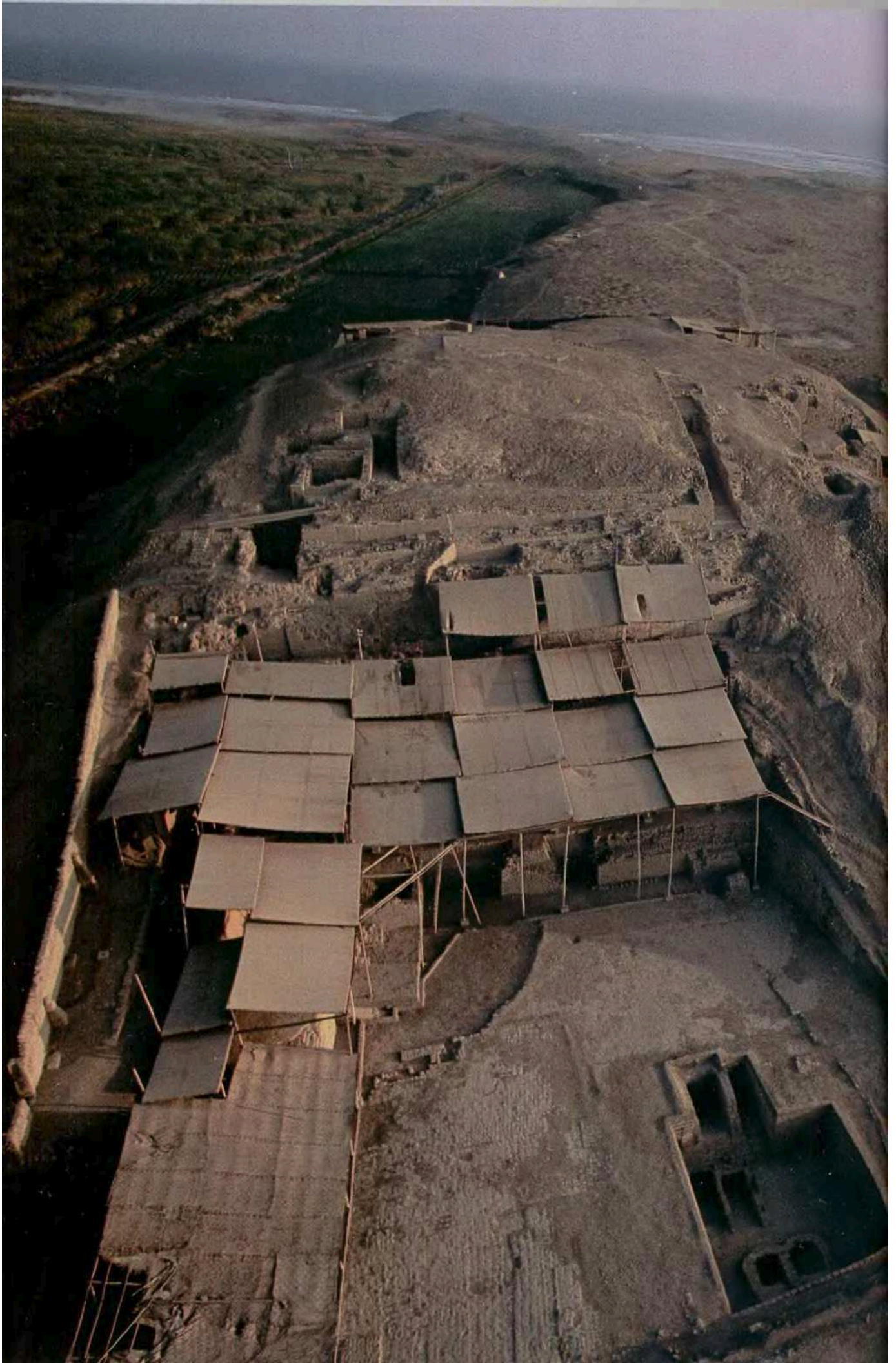
**THE MOCHE DID NOT LEAVE  
A WRITTEN LANGUAGE,  
BUT THEIR ARTWORK  
PORTRAYS A VIBRANT-  
AND VIOLENT-CULTURE.**

"Beware all who enter" could have been the message of the decapitator god, a head-taking deity worshipped by the Moche. Shown here as part man part spider, his grim visage guards the door to a recently excavated and once sacred room in Huaca Cao Viejo, El Brujo's largest pyramid. Digging in the Moche Valley in 1899, German archaeologist Max Uhle was the first to realize that the region held graves and ruins of a people then unknown to historians. Later named for the valley, the Moche reigned from about A.D. 100 to 800.














MOCHE PYRAMIDS, WHICH  
OFTEN HELD RICH TOMBS,  
HAVE ENDURED CENTURIES  
OF FLOODS AND LOOTERS.

**W**hen Peruvian archaeologist Régulo Franco first saw the ruins of El Brujo in 1990, his heart sank. Hundreds of looter holes pocked the landscape. "It looked like the moon," he recalls. But Franco noticed something in the rubble that gave him hope: Part of an ornate frieze showed a life-size man with a rope around his neck. After that, he says, "I suspected this place still held many secrets."

From above, El Brujo's Huaca Cao Viejo (left)—a mud-brick pyramid, or *huaca*, situated by sugarcane fields and the Pacific shore—reveals little of its former splendor. Centuries of flooding have transformed what was a grand cathedral of the Moche era into a mud mound. But beneath roofs they built to protect the site, excavators have dug out a warren of rooms and terraces decorated with colorful wall art.

Serving as religious centers along a 300-mile stretch of Peru's coast, dozens of pyramids dot arid valleys where the Moche built farming and fishing communities and made exquisite pottery and jewelry. Over time, Spanish explorers and others looted most of the pyramids' treasures. Archaeologists have found little gold in Huaca Cao Viejo, but its art casts a spell. Says Franco, "I expect to be here a long time."

**BY PETER GWIN**  
NATIONAL GEOGRAPHIC WRITER

**PHOTOGRAPHS BY IRA BLOCK**





ART BY JOHN DAWSON



**IN ITS DAY THIS  
PYRAMID, OR  
HUACA, WAS AN  
ARCHITECTURAL  
WONDER.**

Built in seven phases (circa A.D. 100 to 700), Huaca Cao Viejo included a plaza larger than a football field and a six-tiered pyramid (above). An unlooted Moche tomb was found in 1988 at Sipán (map), eighty miles north. (Read about more Moche sites in the March 2001 issue.)

**■ SOCIETY GRANT**

This Research Committee project is supported by your Society membership.





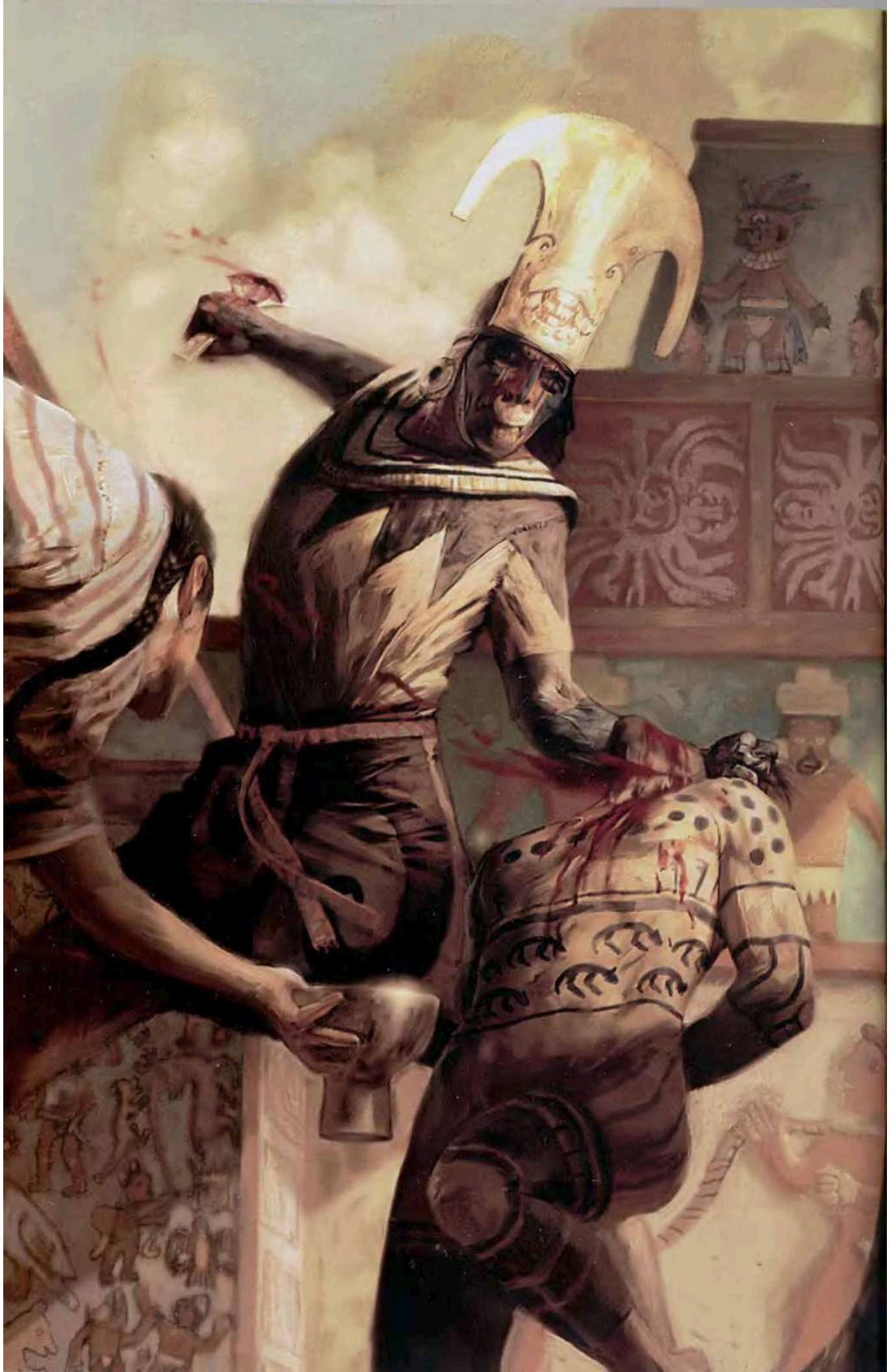
## THEY WHO WERE ABOUT TO DIE

For prisoners of the Moche, Huaca Cao Viejo's elaborate art (below) was likely among the last sights they saw. Naked, bleeding, and bound with nooses, they were led into the ceremonial plaza. Perhaps they heard the Pacific surf rolling onto the beach in the distance; perhaps all they heard was the pounding of their own hearts. Once inside they witnessed one of history's most gruesome sacrificial rites (following pages). A Moche priest adorned in gold slit their throats one by one. Those in line who didn't turn away or faint saw a priestess catch the blood in a golden goblet for the priest to drink. Scholars know about these ceremonies by studying Moche artwork, like the frieze of naked prisoners (above) discovered on Huaca Cao Viejo's plaza wall. Bones of sacrifice victims—incorporated into the frieze and buried under the plaza floor—show evidence of extreme torture before the grisly executions. Still debated: Were the prisoners locals or foreigners captured in battle?

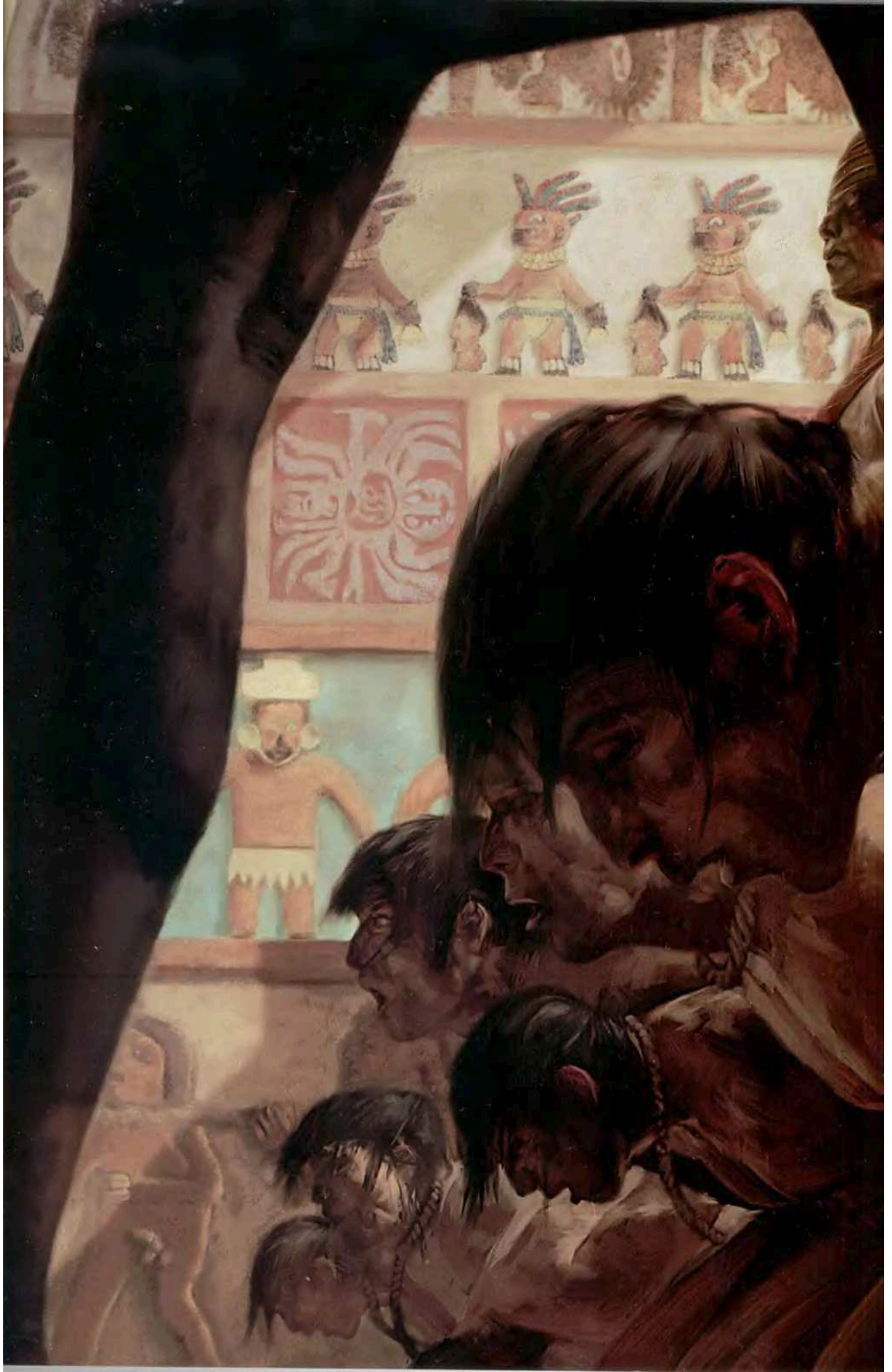
ART BY JON FOSTER  
(FOLLOWING PAGES)













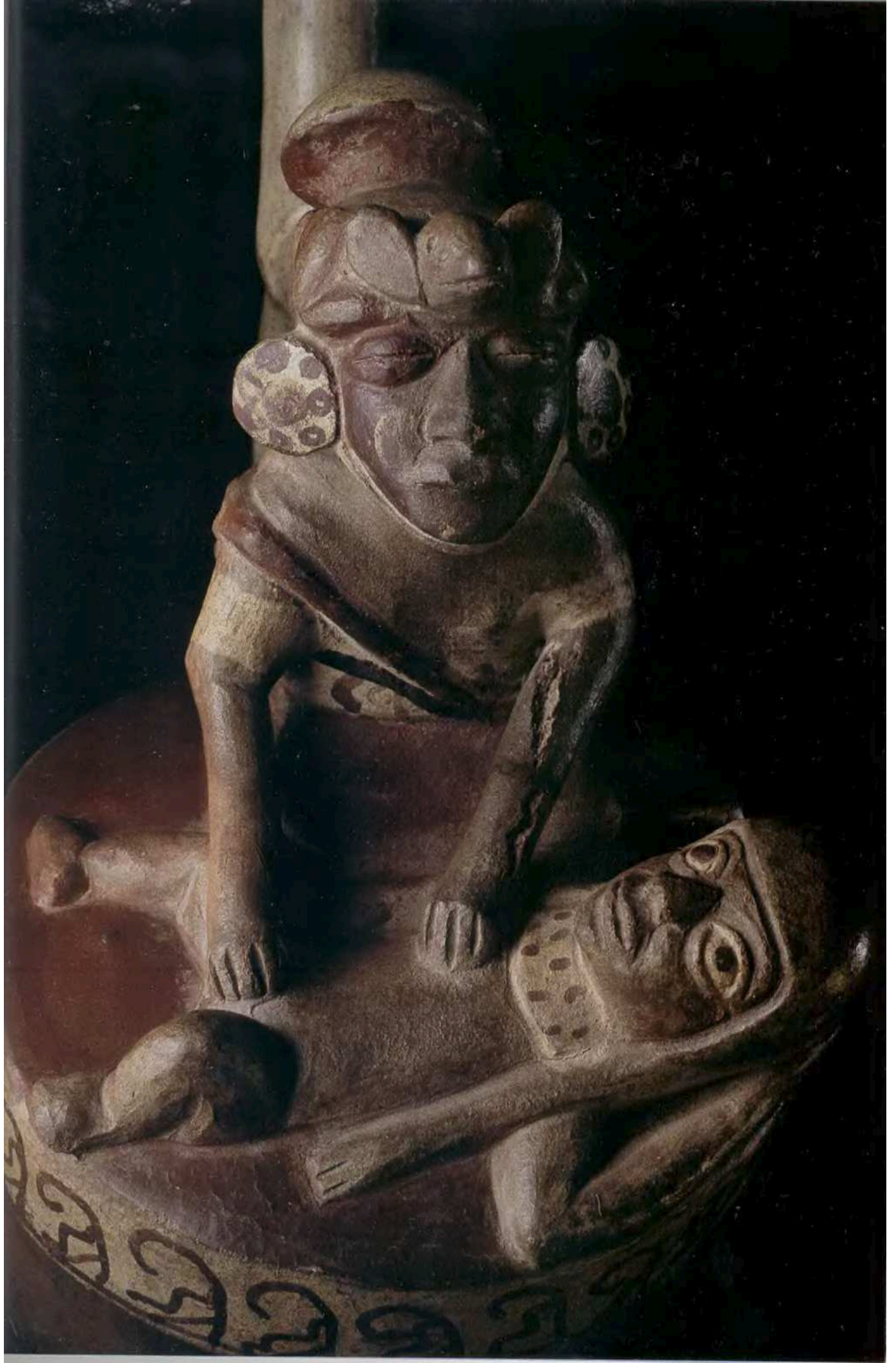


### CRACKING THE MOCHE CODE

Régulo Franco (below, at right) and his team unearthed parts of two friezes that may help explain the Moche religion. The works display a jumble of characters, such as a warrior (top left) and a man wearing what appears to be a five-point crown (top right). Franco believes this figure personifies the planet Venus—the crown signifying its bright light—and that the mural is a calendar showing when to hold ceremonies. Huaca Cao Viejo also has yielded ceramics with religious themes. One vessel (right) depicts a shaman performing a healing ritual on a woman. Franco says they may be in a trance induced by a potion made from the San Pedro cactus, a hallucinogen Peruvian shamans still use today.



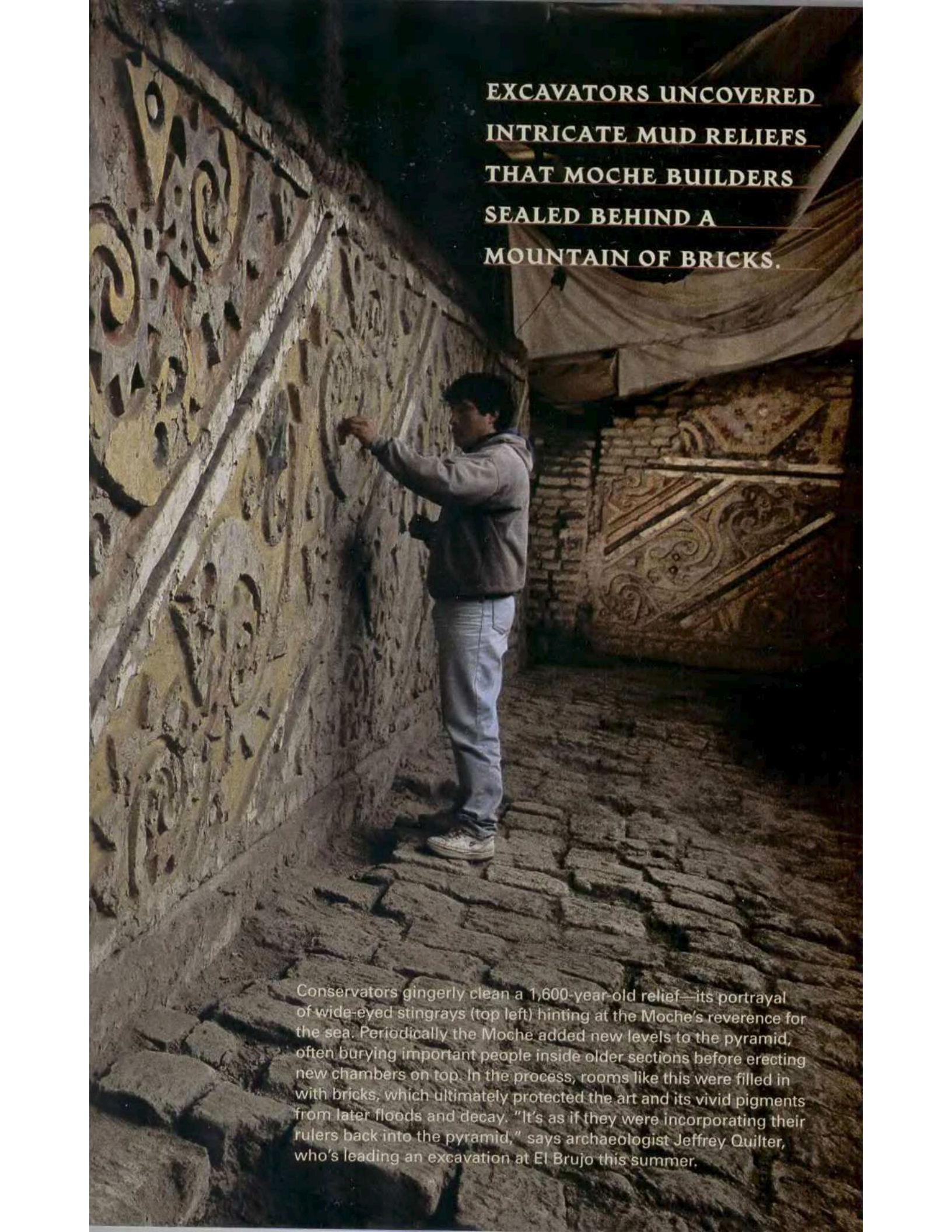








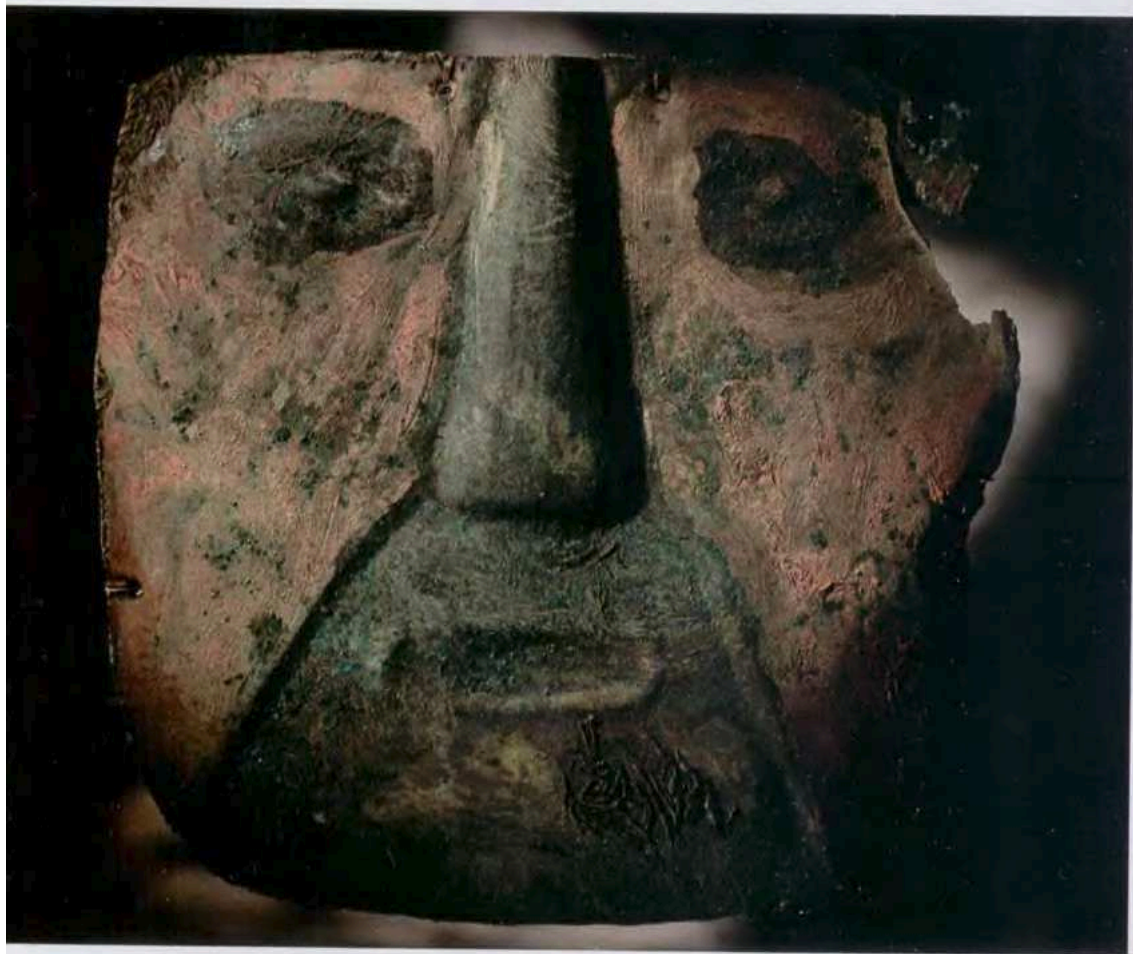




**EXCAVATORS UNCOVERED  
INTRICATE MUD RELIEFS  
THAT MOCHE BUILDERS  
SEALED BEHIND A  
MOUNTAIN OF BRICKS.**

Conservators gingerly clean a 1,600-year-old relief—its portrayal of wide-eyed stingrays (top left) hinting at the Moche's reverence for the sea. Periodically the Moche added new levels to the pyramid, often burying important people inside older sections before erecting new chambers on top. In the process, rooms like this were filled in with bricks, which ultimately protected the art and its vivid pigments from later floods and decay. "It's as if they were incorporating their rulers back into the pyramid," says archaeologist Jeffrey Quilter, who's leading an excavation at El Brujo this summer.





### A CULTURE DISAPPEARS

Archaeologists have noted evidence of flooding and earthquakes that could have ruined the irrigation canal systems critical to Moche farms. They suspect that a series of El Niños—which altered ocean currents, disrupted fishing grounds, and dramatically increased rainfall—drove the Moche from coastal river valleys in the eighth century when they dispersed, leaving little evidence of their fate.

After the Moche were gone, later cultures regarded their pyramids as sacred. Archaeologists have exhumed a number of artifacts dating from the Lambayeque people (circa A.D. 900), including a copper mask (above) buried in front of Huaca Cao Viejo. Such objects carry steep price tags on the antiquities black market, as evidenced by the legions of looter holes near a well (right) at the excavation site. Scholars can only wonder what has been lost. One tantalizing exception is a star-shaped gold ornament (above right) dug up in Huaca Cao Viejo, possibly related to the calendar mural. More rooms, their contents unknown, lie buried, awaiting discovery by Franco and others eager to learn their secrets. □





LOOTERS HAVE  
SCoured EL BRUJO  
FOR CENTURIES  
HOPING TO FIND A  
HIDDEN CACHE OF  
MOCHE GOLD.



CHAN CHAN MUSEUM, NATIONAL INSTITUTE OF CULTURE (PAGES 103, 113, 117 TOP);  
EL BRUJO PROJECT, NATIONAL INSTITUTE OF CULTURE (PAGE 116)

**ZOOMING IN ON THE MOCHE** Learn how photographer Ira Block got aerial shots—roped into the seat of an open-air plane—then visit an online gallery of Moche images and find resources and related websites at [nationalgeographic.com/magazine/0407](http://nationalgeographic.com/magazine/0407).





ZipUSA

NALCREST, FLORIDA

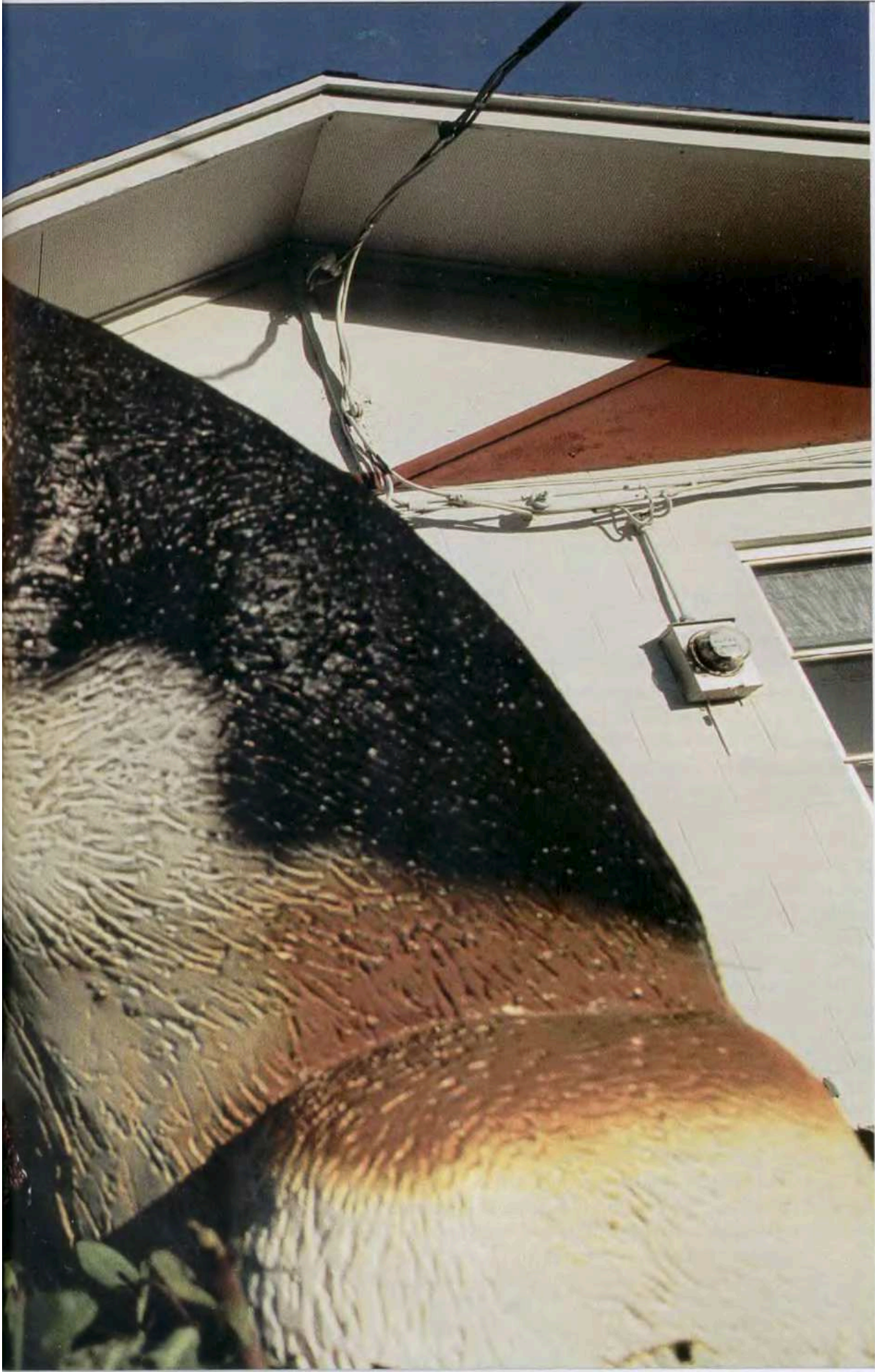
# 33856

## No Dogs Allowed

BY MELBA NEWSOME PHOTOGRAPHS BY DAVID McLAIN

Beware of . . . lawn art? Framed by a plastic beagle, retired mailman (and dog lover) Rich "Downtown" Brown relaxes in Nalcrest. Built for retired letter carriers, Nalcrest bans live canines—the bane of mallmen everywhere.







## NALCREST, FLORIDA



Where do retired mail carriers go before they reach that great dead-letter box in the sky? Try Nalcrest, Florida, a small community along a sparse stretch of Route 60 east of Tampa where you won't find boring blue uniforms, change of address slips, six-day-a-week delivery schedules—or dogs.

That bothers Rich “Downtown” Brown, a wiry chain-smoking malcontent. Despite being bitten several times on his New Jersey route, he remains a dog lover. “I guess we’re not allowed to have dogs because of all the old people,” says the 60-year-old Brown. “They have walkers, and the dogs might have walkers too.”

Of course, fear of dogs on walkers isn't the reason behind the ban. No one quite remembers what is behind it, though the town's general manager, Jerry Kane, believes the rule was implemented for “sanitary reasons.”

Whatever the rationale, Brown sees it as a loss. He flips open his wallet to show off a picture of Kemosabe, the Siberian husky he had for 13 years before coming here. Now he makes do with Digger, the south end of a northbound plastic beagle he has staked in his garden. “He’s the only and official dog of Nalcrest,” Brown says proudly of his lawn ornament—which is the closest anyone here seems to come to civil disobedience.

On the Sunday before Thanksgiving, the town's population has swelled with hundreds of part-time residents fleeing cold weather. They trickle in to the auditorium for one of the community's seemingly endless fund-raisers. This time it's breakfast where, for \$3.50, you get scrambled eggs, hash browns, sausage, toast, and all the gossip you can handle. “He looks awful,” says one man of a recently hospitalized resident. “He’s 80 years old, but he’s still a nasty bastard!”

The softball doubleheader two days earlier is also a hot topic of conversation, particularly for Walter Oppermann, the self-appointed waiter who sprints between tables. The Nalcrest team won both games over the town's much younger

**“Only hip people move to Florida. The grouches stay home.”**

**—JOAN HERMAN,  
WIFE OF RETIRED  
MAILMAN**

At the helm of his boat, named *Rolling Thunder*, Rich Brown leaves a wake on his way to Lake Weohyakapka. With waterways, a ball field, and lots of bingo—not to mention cheap rents on its 500 apartment units—Nalcrest (below) suits retirees who spent their careers outdoors and on the go.

Tallahassee Nalcrest



33856

POPULATION: 800

ACTIVE LETTER

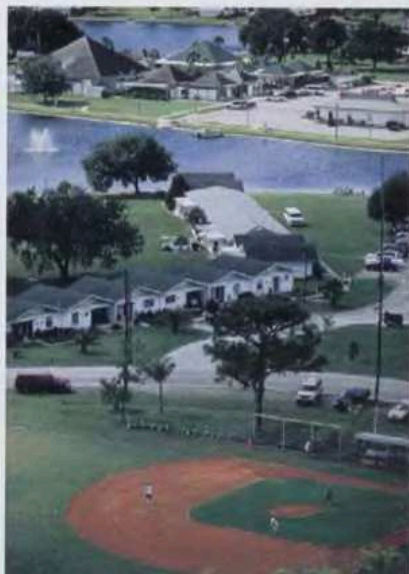
CARRIERS: 0 (P.O. boxes only, please)

YOUNGEST RESIDENT: 55

OLDEST RESIDENT: 92

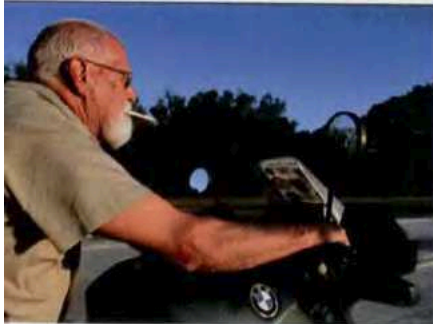
LENGTHIEST STAY:

37 years





## NALCREST, FLORIDA



maintenance crew, and Oppermann, also known as the Rabbit, was the designated runner for several of his teammates. ("We can't expect these guys to run the bases," he says. "Some of them have bad knees, and one guy is 83 years old.") The team is sponsored by Johnson's Funeral Home, perhaps because it's good civics—and perhaps because it's good business. After all, notes 15-year-resident Mable Latulip, "They call Nalcrest God's waiting room."

It's a familiar joke in any retirement community. But this isn't just any retirement community: Nalcrest stands out as an oddity, a town built for union retirees. The NALC in its name stands for the National Association of Letter Carriers, the union for city letter carriers whose longtime president William C. Doherty lobbied for years to turn 300 acres of uninspiring central Florida real estate into a four-million-dollar retirement community. Doherty turned the first shovel of dirt in 1962 and became one of the 500-apartment complex's first residents several years later.

Sure, the community's Lake Weohyakapka had an Air Force bombing range at one end, not to mention alligators. And what if it's so hot in the summer you can barely stand still on the shuffleboard courts? With an efficiency renting for under \$75 in 1964, Nalcrest was nirvana for postal retirees. It remains a bargain: A one-bedroom rents for only \$305, and dinners at Jay Bee's II, the town's only restaurant, average \$6.

The natural surroundings attract as many people as the low prices and warm weather. With half the land still undeveloped, Nalcrest is as much a nature preserve as a town. Hawks soar overhead, sandhill cranes stroll through town and peck at their reflections in windows, and "owls are the size of fire hydrants," says Kane.

And contrary to what you might expect from a community of Cliff Clavens, no one sits around reminiscing about Sears-catalog-induced hernias or half-mile sprints just ahead of an angry rottweiler. They're too busy with the stereotypical senior activities—bingo, bowling, art class. It's a lot like being in college (no jobs, few responsibilities, lots of parties) without the midterms. Just ask George and Mae

**Bill Ryan (above right) says Nalcrest is Shangri-la: "We're just regular blue-collar guys and gals having the time of our lives." Some opt for the open road: George Glascock (above left) cruises on his BMW motorcycle, while Marion Bozman (above center) bikes four-plus miles a day. Others find fun indoors. At the Homecrafters and Service Guild, women make wreaths from plastic bags (below right). Gossip flows at the American Legion Auxillary (below center), and spirits rise at the Literary Club and Choral Society's weekly meeting (below left).**







**“I never had a swing growing up. Before you die, you should really have a few things you never had growing up.” —SUNSHINE BRIGUGLIO**

Glascocock, who cruise around on a BMW motorcycle with a sidecar. Or the all-male Literary Club and Choral Society, where the name Jim Beam can be heard more often at the weekly meetings than that of Hemingway, who seems to be revered more for his drinking prowess than his literary genius.

“I love the sense of community here,” says Annette Alversa, who moved from Long Island several years ago when her postman husband retired after 35 years. “I used to say, ‘I’m never going to live down there with all those old people.’ I woke up one day, and I was one of those old people.”

Unlike Annette, and unlike most women in Nalcrest, Grace Porter did not come here as a spouse. When Porter became a letter carrier in the late 1960s, she was a rarity and is now among the first wave of female retirees. After 27 years of walking up to five miles a day along a Kansas City mail route, Porter moved here in 1999 to put her feet up in a warmer climate. “After I retired, I swore I’d never walk again, says Porter, “but I walk every morning at 5:45.”

The post office remains a regular stop for Porter and fellow retirees. By the time the tiny storefront opens at 10 a.m., a small group has already gathered in the town center around the bronze statue of Richard Quinn, a president of the 115-year-old union. While they appreciate Bob and Edie Raymond, the couple who work behind the small window four hours each day, no one envies them what surely must be the most thankless job in America—processing mail for hundreds of people who are certain they could do it better. □

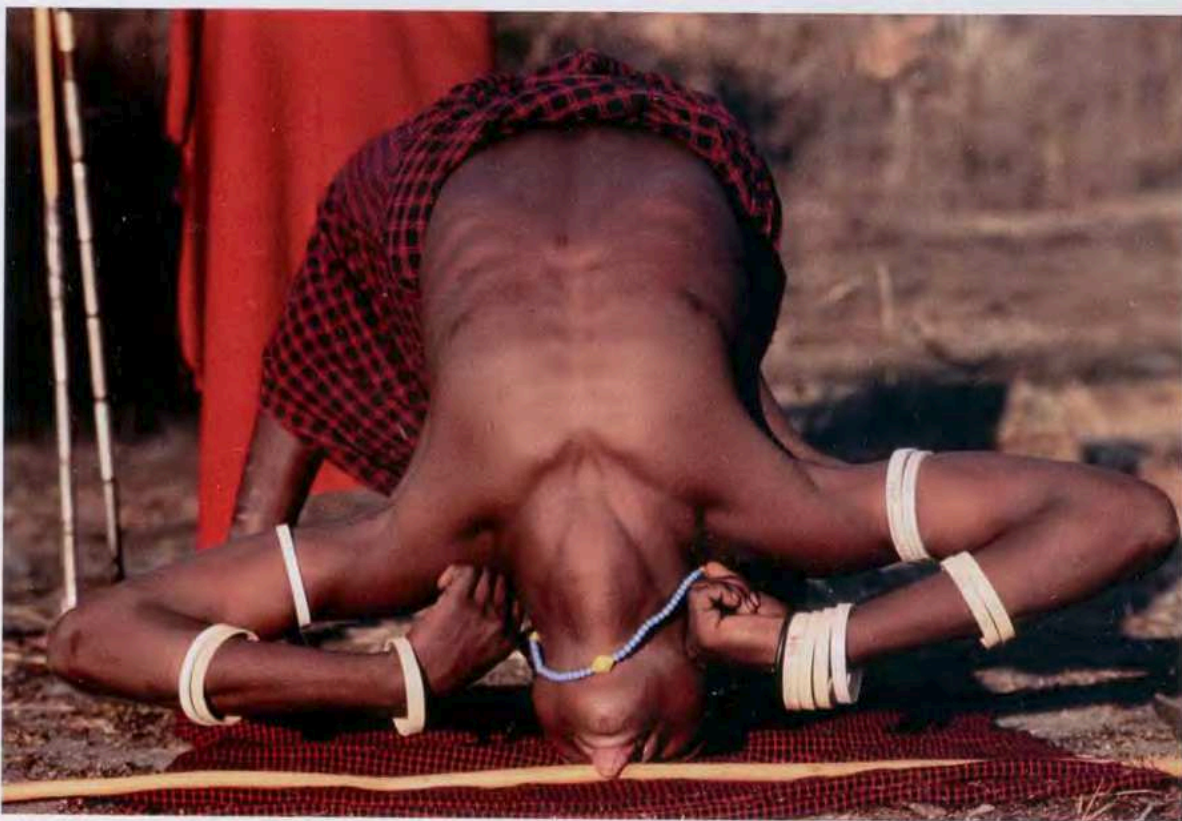
**“It’s a peaceful place to swing your cares away,” says Sunshine Briguglio (above), who enjoys her solitude in a shaded grove. Nancy Sell (below) swims her aches away at a daily aquarobics class at the Nalcrest pool. “Down here everybody accepts everybody else,” Briguglio says. “It’s relaxed.”**



**WEBSITE EXCLUSIVE** Find more 33856 images along with field notes and resources at [nationalgeographic.com/magazine/0407](http://nationalgeographic.com/magazine/0407). Tell us why we should cover **YOUR FAVORITE ZIP CODE** at [nationalgeographic.com/magazine/zipcode/0407](http://nationalgeographic.com/magazine/zipcode/0407).



# Final Edit



BARABAIG

## Tongue Twister

Bending over backward to train for a marathon elephant hunt, a Barabaig man strains to grasp a stick with his mouth, then stand upright without dropping it. The contortion looks painful—and it is. “I tried to do this exercise and couldn’t,” says photographer Gilles Nicolet. “It gave me an awful pain in the neck.”

The ability to bear pain with fortitude and face danger with unwavering courage is paramount to these hunters, whose ultimate test is to slay an elephant or lion using only spears. They prepare for the deadly trial with traditional stick exercises that build strength of body and mind.

Difficult, too, was the decision by our editors to pass up this picture. “It’s a fantastic image,” says design editor Elaine Bradley, “but it’s hard to understand immediately because of the man’s strange position.” Space in the story allowed room for only one exercise shot. The image selected (page 81) was easier to interpret at a glance.

### WEBSITE EXCLUSIVE

Cut it or keep it? Find out more about what tipped the balance for this photograph at [nationalgeographic.com/magazine/0407](http://nationalgeographic.com/magazine/0407).



# ON ASSI

ON THE ROAD, IN THE FIELD

CAQUETÁ

## In Cocaine Country

*Where the drug business is business as usual*

The rebel leaders in Colombia's Caquetá Province gave photographer **Carlos Villalón** carte blanche to cover the region. He moved so easily among the locals, even their pets trusted him (above). But Carlos's camera still occasionally raised suspicions. Once a drunken man accused him of being a spy. "Under the table, he's touching the barrel of his gun to my

stomach," Carlos said. "I'm thinking, this guy is going to shoot me right here." Luckily, the gunman's friends stopped him.

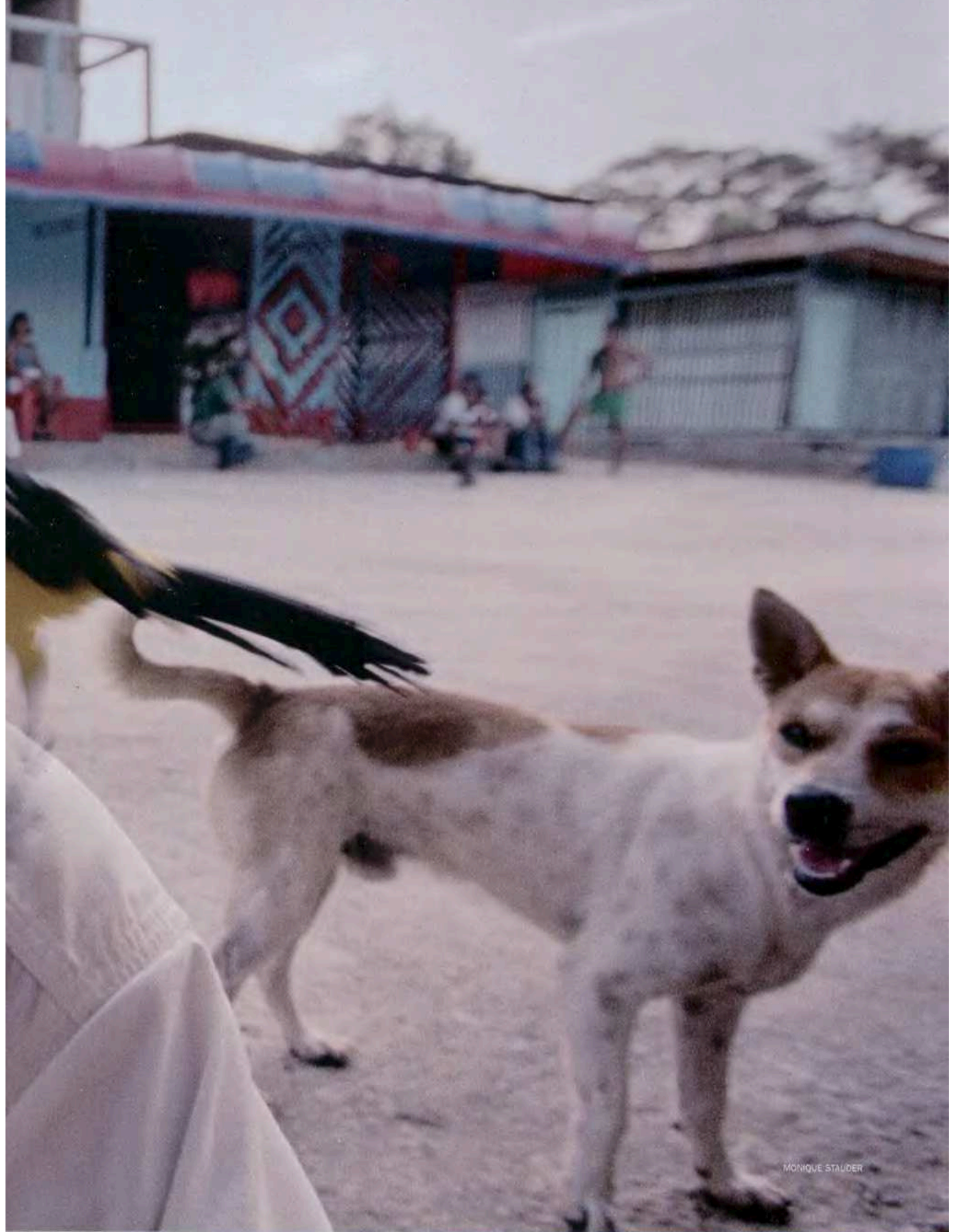
Yet sometimes people forgot that Carlos wasn't one of their own. After eating breakfast at a local café one morning, he asked a waiter how much he owed for the meal.

The man's quick reply? "A gram and a half."



# GNMENT

C O V E R I N G T H E W O R L D



MONIQUE STALDER





DANA ROMANOFF (ABOVE); JERRY KANE

## EL BRUJO

## When Push Comes to Shove

The dry climate of Peru's coastal plain is good for archaeological preservation. "That's part of the reason that things have survived so well at El Brujo," says **Ira Block**, who photographed the site once used

by native Moche shamans.

But the desert's not so great for driving. No paved road runs through it, and the terrain is peppered with hundreds of *huecos*, the deep pits dug by tomb robbers hoping to strike it rich. As Ira

and Mario Vildósola Benavente, his assistant, zigzagged through the soft sand to avoid the holes, Mario boasted "my car can go anywhere." But it wasn't long before the mighty Ira (above) had to help free the vehicle.

"Why was I pushing, and why was Mario behind the wheel?" Ira asks. "That is a very good question."

## WORLDWIDE

"Picture a thousand grandmas," says photographer **David McLain** of his time in Nalcrest, Florida. "I was getting my cheeks pinched every minute. People were trying to marry me off to their granddaughters." David, 35, is a little

young to move to the retirement town. And—sorry, granddaughters—he has a wife. But septuagenarian Sophie Kistner (left) gave him a warm welcome with one of her hand-knit hats. Others felt the need to feed him. "The day I got there, I heard a knock, and there's this little Italian lady from next door holding a steaming plate of homemade gnocchi," says David. "That's a picture I regret missing."

In the middle of the night in Iran, **Mark Moffett's** military escorts were whooping it up in the glow of the light he'd hung to attract wind scorpions. The soldiers didn't know Mark needed to work in the

dark; the other scientists in the expedition had projects with more conventional hours. "The guys are making a racket," he says. "I see this huge wind scorpion run by. But suddenly a boot comes down and smashes it." Mark's subsequent screaming match with the stomping soldier had a happy ending. "Once they understood what I was doing, they helped me run around all night and catch more wind scorpions."

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# Flashback



CORBIS

## THE SUN

### Eclipsed

On June 19, 1936, as Muscovites waited for a total solar eclipse to darken Russian skies, some donned protective viewers designed to filter out retina-burning rays. Others seemed more interested in *Pravda's* news about one of Russia's native sons than in the sun overhead.

Maksim Gorky, beloved novelist and playwright, had died the day before. Despite his stature as the "father of Soviet literature" and head of the Soviet Writers Union, Gorky became disillusioned with Stalin's leadership. Suffering from tuberculosis and heart problems, Aleksey Maksimovich Peshkov (Gorky, meaning "bitter one," was his pen name) died at 68. He may well have been helped along by a fatal dose of poison: Rumors persist that Stalin ordered Gorky's murder. —Margaret G. Zackowitz

#### WEBSITE EXCLUSIVE

You can access the Flashback photo archives and send electronic greeting cards at [nationalgeographic.com/magazine/0407](http://nationalgeographic.com/magazine/0407).